MANORAMA

TELL ME WHY

No:126

THE INVISIBLE FORCE

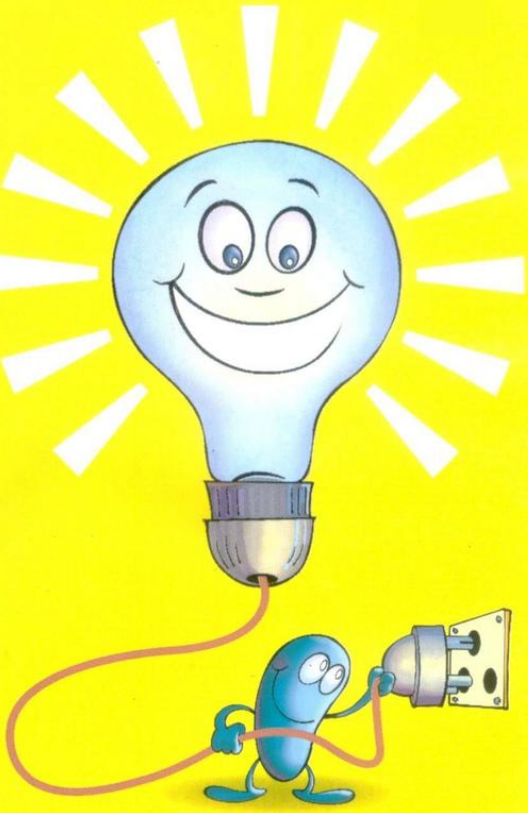
AC & DC

ELECTRO-MAGNETS

ELECTRICITY IN EVERYDAY LIFE

MAKING ELECTRICITY

ELECTRICITY IN FUTURE



STORY OF ELECTRICITY

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MANORAMA
TELL ME WHY
March 2017 • Volume: 11 • No: 3
FROM THE HOUSE OF MAGIC POT, THE WEEK, MANORAMA YEARBOOK, VANITHA & THE MALAYALA MANORAMA DAILY

The Master Servant

It is the invisible force that runs through the veins of the modern world, making it go. It is so much a part of our lives that its presence is almost ever taken for granted.

Electricity is a natural force that was tamed and put to use by Man, many centuries ago. It is like a servant turned master. As Man's lifestyle improved, through countless inventions and innovations, the support of electricity became vital to His existence. Absence of this invisible servant would leave the present-day world powerless and dead.

This issue of Tell Me Why tells you the fascinating story of this vital force that rules the modern world - Electricity.

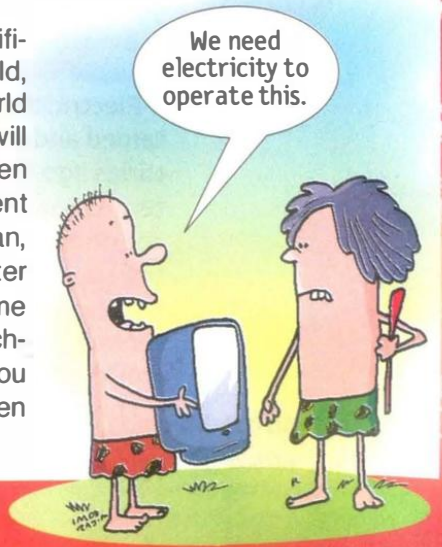
THE STORY OF ELECTRICITY

Why is it said that the introduction of electricity changed the course of mankind?

There have been an indefinite number of inventions that have changed the very course of the world, making it the amazing place that we now live in. But few have had as much impact as electricity.

To understand its significance better, one should, rather, think back to a world without electricity. This will take us back to a time when there were no equipment like the TV, refrigerator, fan, mixer grinder, or computer and even worse, a time when the world went pitch-black after dusk. Don't you think this must have been quite difficult?

Electricity, therefore, has been a path-breaking innovation that made life easier and more comfortable. As years passed, more inventions favoured by electric power were made. Hence, it goes without saying that the change caused by the introduction of electricity is unparalleled, and a life without it, unimaginable.



What is meant by electricity?

Electricity, in its simplest terms, is a form of energy. It can also be associated with the presence of electric charge.

Electricity is usually produced by converting other sources of energies like coal, natural gas, oil, wind, solar, nuclear power etc.

To understand the movement of electric charge, one has to firstly know about atoms. You might have heard of atoms already. Every matter in the Universe- including the human body, air, and water- is made up of atoms. They, in turn, are made of even smaller particles. At the centre of an atom, lies a nucleus, that is formed by positively charged protons, and neutrally charged neutrons. Negatively charged particles called electrons spin around the nucleus.

The number of electrons moving around the nucleus

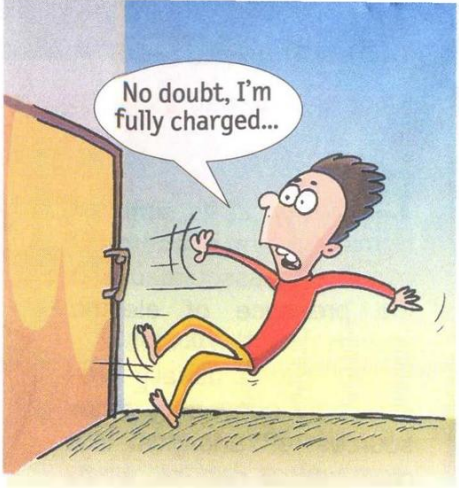
is equal to the number of protons in the nucleus. The charge of a proton is equal and opposite to the charge of an electron. It is also to be noted that all these constituents are extremely tiny.

In electricity the particle moved is the electron which carries a charge designated as negative. In other words, the movement and accumulation of negatively charged electrons in relation to protons, create electricity.

STAR FACT

Did you know?

It was the English scientist William Gilbert who introduced the term 'electricity'. He is also credited with being the first to make scientific observations on frictional electricity, towards the end of the 16th century. The findings were published in his book 'De Magnete'.

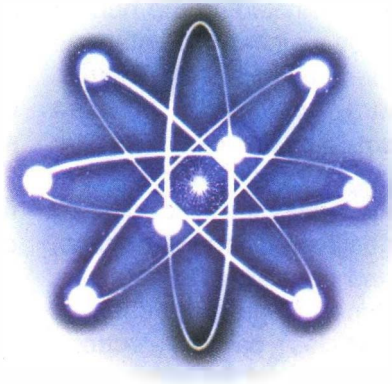


Why is electric charge important?

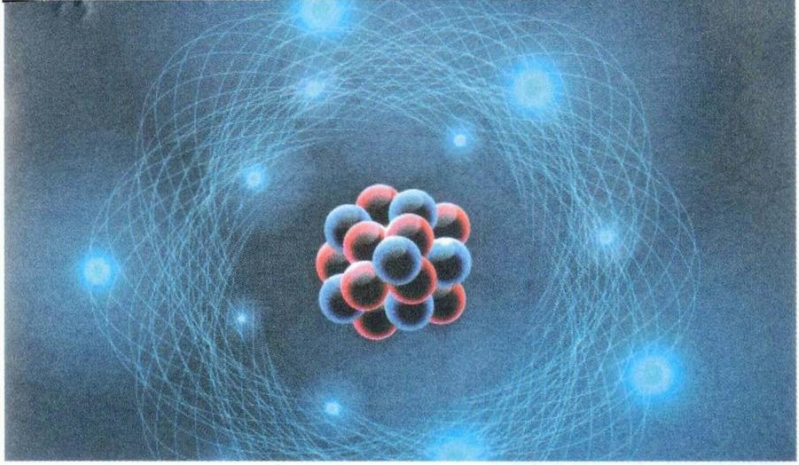
Electric charge is the physical property of matter.

There are two types of electric charges:positive and negative. Like charges (positive and positive, for example) repel, and unlike charges (positive and negative) attract. The most common charge carriers are the positively charged proton and the negatively charged electron. An object is negatively charged if it has an excess of electrons.

As per the International System of



Electrons moving around the Nucleus in different paths.



Visualisation of Protons and Neutrons at the centre and electrons moving around the nucleus in an atom.

Units (SI), the unit of electric charge is coulomb, which is equivalent to about 6.242x1018 e. In electrical engineering, the unit is seen as ampere-hour (Ah), and, in chemistry, it is common to use the elementary charge (e) as a unit.

By convention, the charge of an electron is –1, while that of a proton is +1. The quantity of electric charge can be measured with an electrometer.

The study of charged particles, and how their interactions are mediated by photons, is called quantum electrodynamics.

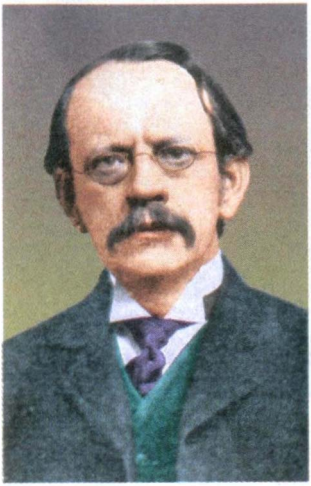
Why was the discovery of protons important?

A proton is the positively charged subatomic particle located inside a nucleus.

Protons are important because it is their number that determines the element (of which the atom is part) and its chemical properties.

To put it simply, the number of protons in an atom, or the atomic number, defines the type of an atom. Thus an oxygen atom differs from a helium atom on the basis of its atomic number. That number is denoted by the letter 'Z'.

The word 'proton' was derived from a Greek word meaning 'first'. It was named



J.J. Thomson

by Ernest Rutherford in 1920. One or more protons are present in every nucleus. Together, protons and neutrons form what is known as nucleons.

Further, protons are made up of invisible particles called 'quarks'. There is a strong nuclear force that binds these quarks with each other. It is also the same force that primarily contributes to the mass of the proton, rather than the quarks themselves.

Who identified the electron?

Electrons, as we know, are negatively charged subatomic particles. They are very important because of their role in various physical phenomena such as electricity, magnetism, etc.

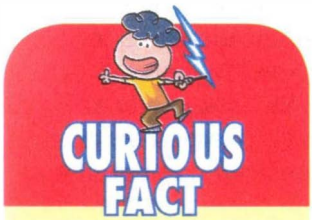
The history of electrons dates back to 1838, when Richard Laming put forth the concept of an indivisible quantity of electric charge to explain the chemical properties of atoms. Years later, in 1891, Irish physicist George Johnstone Stoney named this charge 'electron'. Six years after that, British physicist J.J. Thomson identified the particle. The word 'electron' is thought to be a combination of the words 'electric' and 'ion'.

Inside the atom, electrons are in constant motion, revolving around the nucleus.

They possess a certain amount of energy to maintain distance from the oppositely charged protons inside the nucleus.

What is meant by electric current?

Usually we talk about electricity as current. But are the two same? No!



Charged Experiments!

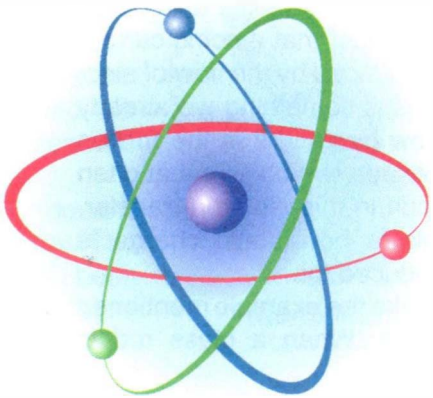
It is said that scientists in the past used electric charges to study the nature of electricity. One of the earliest instruments that helped in generating electric charges was the electrostatic generator, developed by Francis Hauksbee.

Let's see why. As we have seen earlier, electricity is a form of energy. But electric current, on the other hand, is the movement of electric charge.

Let's put it better. It is the flow of charged particles through a medium such as a wire. Similar to water molecules moving down a river, charged particles move down a 'conductor' giving electric current. Conductor means anything that allows the movement of electric current for example, metals, and some liquids.

Electric current is measured using a device called an ammeter. The conventional symbol for current is I.

The intensity of electric current is measured in terms of 'ampere', named after the French scientist Andre-Marie Ampere, one of the founders of classical electromagnetism.



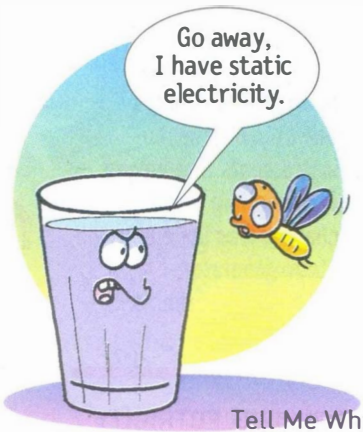
Lightning- An example of Static Electricity

What is meant by static electricity?

Static means steady, or unmoving. In physics, static electricity refers to that electricity which remains steady in a charged body. It is something that we come across in our daily life. An easy example could be the electricity produced when an object like a glass rod is rubbed against a piece of silk. Wonder how that happens? Let's get to know.

The fact that electric current is produced by the flow of electrons is something we already know by now. It is the friction between two objects that often result in this electron-transfer. This is how static charge is produced too.

Take the example mentioned above. When a glass rod is rubbed against a piece of silk cloth, a few electrons from the rod moves to the cloth. As a result, the silk material turns negatively charged because of the excessive number of electrons. At the same time, having lost electrons, the rod becomes positively charged. As the process of rubbing con-



tinues, charge accumulated on the glass rod increases, and the pool of electrons that is formed on the other end creates what is known as 'static electricity'.

Why is it said that the secret of static electricity was known to ancient Greeks?

The Ancient Greeks tried to study it some two thousand years ago. The man behind this attempt is known to be Thales of Miletus. He did research on the principle of static electricity.

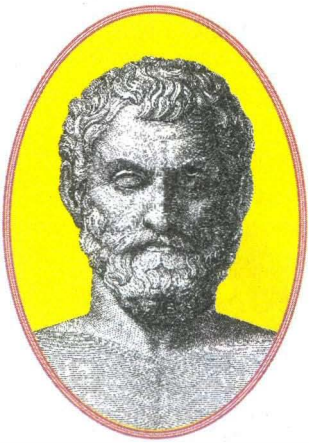
Around 585 BC, Thales conducted many experiments related to static electricity, a concept which was not conceived till then. He rubbed fur and clothes against amber to study more about the phenomenon.

Amber is fossilized tree sap which is a plastic-like non-conducting material. Although he could not identify the secret force behind it, Thales was smart enough to see through attraction between unlikely objects. He could not have completed his study due to lack of resources and tools.

The Greek contribution doesn't end with this incomplete study. The very word 'electricity' has been derived from the Greek word 'elektron' meaning 'amber'.

Almost Everything!

American inventor Thomas Alva Edison is credited to have made more than 2000 inventions, including almost everything that we now use in our houses related to electricity- switches, fuses, electricity meters etc.



Thales of Miletus

What are conductors?

You may have heard about conductors already. They are materials that allow electrons to flow freely from one particle to another. The capacity to transmit something such as heat or electricity is termed as conductivity. Depending on their conductivity, solids are classified as semiconductors, good conductors, and insulators.

Objects that completely allow the passage of electricity are called good conductors. Pure silver is perhaps the best conductor we see around. Some liquids are good electric conductors too.

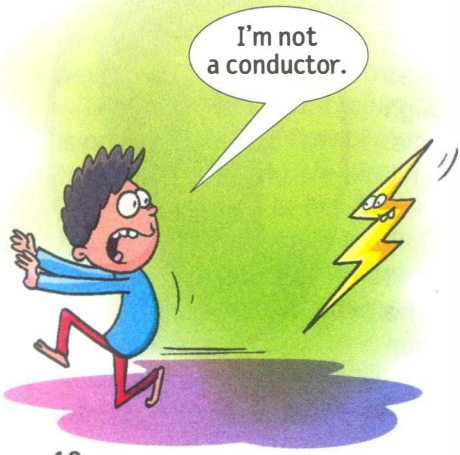
Silver Bars

Generally, gases are considered to be poor conductors. This is because their atoms are too far apart to allow free flow of electrons.

Our body is said to be a good conductor of electricity. That is why we tend to receive electric shock from appliances or electric equipment.

Insulators, on the other hand, do not permit the flow of electricity at all. Among the commonly seen insulators are glass, plastic, mica etc.

Some materials like germanium and silicon belong to the category of semiconductors. This means they conduct electron flow under certain conditions. Otherwise, they act as poor conductors.



CURIOUS FACT

High Speed Electricity!

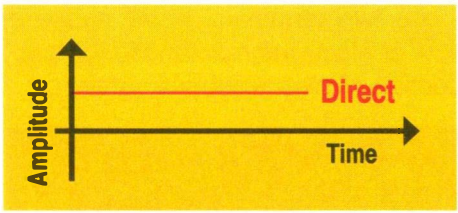
Scientists have proved that electricity travels at the speed of light. That would be more than 28,51,02,627 metres per second!

What is meant by AC?

Electric current moves often like a water stream. The only difference here is that electric charges do not always move in the same direction. When they do, it is called Direct Current or DC.

On the other hand, AC or Alternating Current, as the name suggests, occurs when charge carriers in a conductor, or semi conductor, reverse their direction of movement in a periodic manner.

With AC, it is possible to run many types of electrical equipment like generators, motors, power distribution systems etc. and also kitchen appliances, TVs, electric lamps etc. Hence, for almost all high power applications, it is a global trend to use AC instead of DC because of its higher efficiency. Besides these advantages over DC, AC power is believed to be less expensive. One can also use high voltages with small currents to reduce losses, with AC power.



Direct Current- Graphical Representation

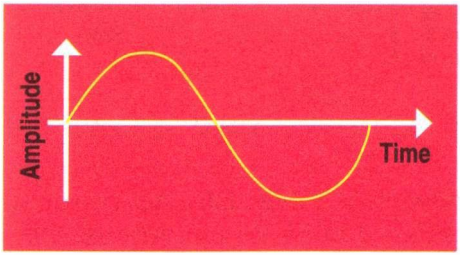
It was in the 1850s that the alternating current technology first surfaced in Europe. One of its pioneers is the French inventor Guillaume Duchenne.

What is meant by the term DC or direct current?

Alternating current, as we saw, periodically reverses its direction,

whereas direct current (DC) flows always in the same direction. The amount of current can change in a DC circuit, but their general direction remains the same.

Perhaps the best and the simplest example of direct current is a battery. Take a look at one of them in your house. You can spot two terminals- +ve and -ve. If a wire is connected to these two terminals, it will cause a flow of electrons resulting in the production of electricity.



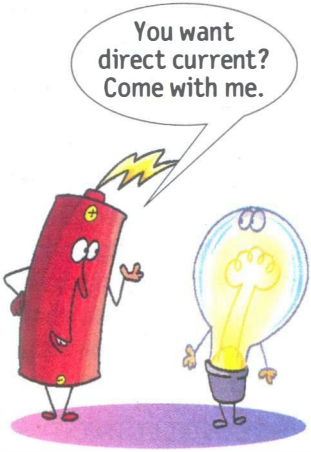
Alternating Current- Graphical Representation

Other than this, direct current is used as power supply for electronic systems and also for charging batteries. DC is thus used for many purposes, though for smaller and less complicated ones, unlike AC power. But direct current can be converted to alternating current through devices like an inverter or a motor-generator set.

Direct current is produced by various sources such as solar cells, dynamos etc. It mainly flows in good conductors such as wire, but can also flow through semiconductors, insula-

The Biggest Source

Coal is the biggest source of energy for producing electricity. Burning coal in furnaces heats water until it generates steam. It is then used to drive turbines to produce electricity.



tors and even vacuum.

Electric current in DC is measured in ampere and voltage in volts.

Why is it said that the earlier power transmissions used direct current?

Direct current, as we know, is the flow of electric charge in just one direction. The history of electric power records that the first commercial transmission was made possible using direct current.

This was perhaps because DC was the only option then. But as time passed, it proved to be insufficient. Because, with direct current, voltage couldn't be changed easily. What made it worse was that, different classes of loads, for instance, lighting, motors, railway systems etc, required different voltages. So for this, there had to be different generators and circuits.

However, in the course of time, alternating current took over and electric transmission became easier than before. We have seen that this type of current can reverse its direction, and serve better than DC. In 1884, the first long distance AC line was built in Italy, proving that AC

An Electric Substation

was better for long distance transmission.

As years passed, newer technologies were introduced. By the mid 1950s, an advanced type of direct current transmission was developed, and was named the high voltage direct current transmission. Today, it is the alternate and the most acceptable option for long distance, bulk transmission of electric power, especially between countries.

Alessandro Volta

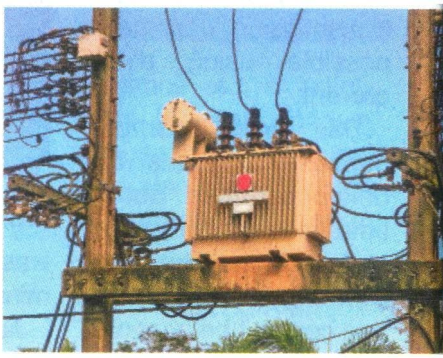
Why does voltage play a significant role in power transmission?

All of us have heard of the term 'voltage' at some point. But how many of us know what exactly it is?

Let's try to understand with an example. If water has to pass through a hose, it needs some force from behind, doesn't it? This force, in the context of electric power, is voltage.

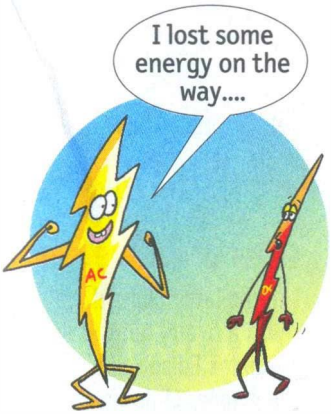
So technically, voltage is the name given to the electric force that causes electrons to flow from one atom to another. It is usually supplied by a battery or generator.

One can observe voltage in the electrical appliances that we commonly use. We often see the brightness of light bulbs dimming. A reason for this could be a change in voltage. So, as the voltage increases, electric supply too increases. Devices called stabilizers are used in most of the domestic appliances like TV's or fridges, to stabilize voltage.



A Transformer

Voltage is measured in units of volts, and the equipment used for the purpose is called voltmeter. The term voltage was named after an Italian physicist Alessandro Volta.



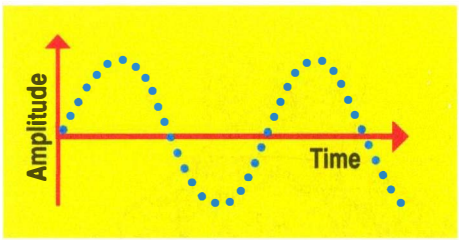
Why do we use AC supply in our homes?

Initially, direct current was used for power transmission. It was only in the 1950s that people realised the merits of alternating current over the other.

Although the two are used today, alternating current is more accepted worldwide. It is used for bigger appliances as well as in houses. Let us see why.

One of the main reasons for having AC for domestic purposes is that it causes very low wastage of power. It is seen that even at high voltages above 110 KV, less energy is lost in transmission. Yet another peculiarity of AC electricity is that voltage can easily be changed from high voltage to low and vice versa. This in turn makes it suitable for long distance transmission, unlike DC.

Alternating current is also known to be capable of powering electric motors. Thus, it is useful for high-end appliances like refrigerators, televisions, computers etc.



AC - Graphical Representation

In terms of safety too, AC is preferred to DC power.

It is for these reasons that most countries in the world favour AC than DC power.

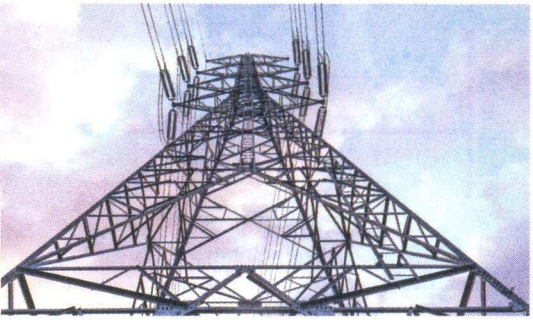
What is high voltage direct current?

A high voltage direct current (HVDC) is a transmission system that uses direct current for transmission of electric power in large quanti-

ties. Or, in other words, it is a technology used to transmit electricity over long distances. HVDC is also called a power super highway, or electrical super highway.

We have seen that alternating current is preferred to direct current for various reasons, including financial. To address this, as well as other difficulties, HVDC can be used, as they are less expensive and suffer lower electrical losses.

In this technology, electricity is transmitted through overhead transmission lines, or submarine cables. According to experts, the advantages of HVDC include lower investment cost, long distance water crossing, controllability, lower losses etc. It also causes lower environmental impact compared to AC.



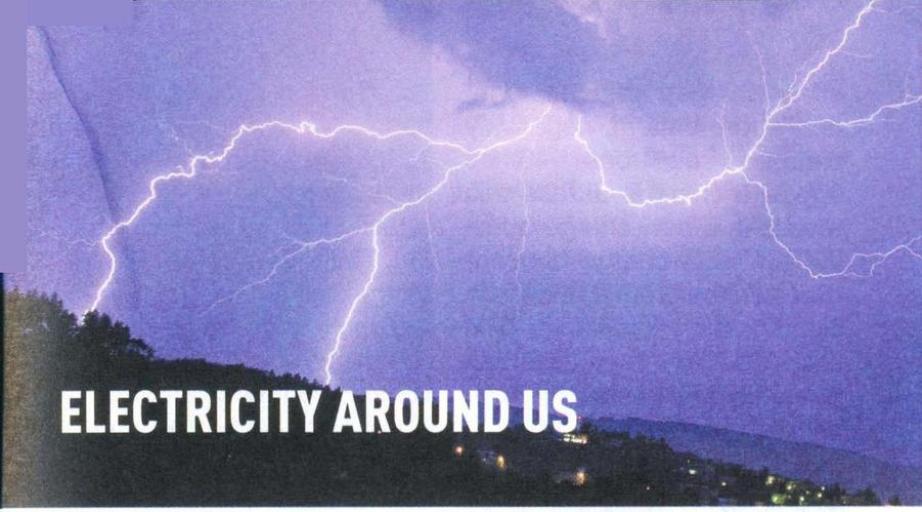
Overhead Transmission Lines

It was in 1882 that the first long distance transmission of electric power was demonstrated using direct current, in Germany. In the 1930s, the technology was further developed in Sweden and Germany. The modern form of HVDC also uses this technology.

The Rio Madeira link in Brazil is the longest HVDC link in the world. The length of this link is 2385 kilometres.

War of Currents

In the late 1880s, there was a rivalry between Thomas Edison, the developer of direct current, and Nikola Tesla, who developed the alternating current. This fight over supremacy of currents is popularly known as the War of Currents.



ELECTRICITY AROUND US

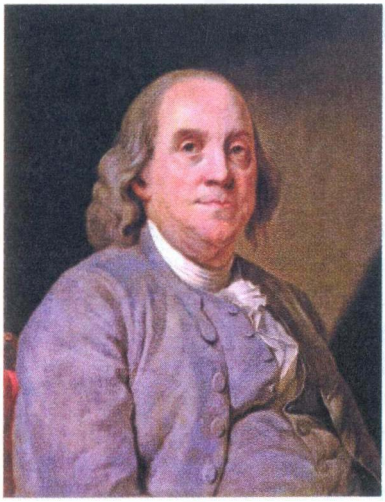
Why is it said that lightning is one of the major sources of electricity?

Lightning could be attractive to a few and scary to others, but it is definitely a phenomenon that stirs one's curiosity! How many of us know that it is a powerful burst of electricity that happens very quickly during a thunderstorm?

Technically, lightning is caused by an electric charge in the atmosphere. It is known to contain millions of volts of electricity. Lightning can occur inside, or between the clouds.

Let's see how lightning happens. Within the thunderclouds up in the sky, there are bits of frozen raindrops that rub against each other. This collision creates an electric charge. As it continues, the cloud fills up with electric charge. On top of the clouds the posi-

tively charged protons form, and at the bottom, negatively charged electrons. Since opposite charges attract, this results in a new charge building up. This charge concentrates on the ground under the cloud, mostly on things that stick up like mountains, tall trees, electric posts and even people.



Benjamin Franklin

Why is it said that Benjamin Franklin studied electricity a great deal?

Benjamin Franklin firmly believed that electricity and lightning had close similarities.

One of his inventions was the lightning rod, a simple rod attached to the top of a building. The rod was meant to protect houses from the destructive forces of lightning. As the electric charge from lightning strikes the rod, it would conduct the charge harmlessly into the ground, saving the house and its occupants.

Franklin made a description of this invention in 1753. He is also credited to have coined terms like battery, conductor, electric shock etc.

It is believed that Franklin began his experiments on electricity in 1746. Two years later, he created a multiple plate capacitor which he called an electrical battery. The capacitors were wired together sequentially to store more charge than one alone could. This helped to produce a bigger discharge of static electricity. For his contributions to the study of electricity, Benjamin Franklin received the Royal Society's Copley Medal in 1753.

Benjamin Franklin's Kite Experiment- A Painting

Why was Benjamin Franklin's kite experiment an important one?

Benjamin Franklin conducted the famous kite experiment in Philadelphia, USA. The experiment was done to understand the 'mystery' behind lightning and electricity. Let us see how it took place.

The inspiration for the kite experiment came from Franklin's conviction that lightning and electricity had close similarities. To prove this, he went out with his son on a dark afternoon on June 10th, 1752. They attached a silk string to the kite, and tied an iron key to its end. Then, they tied a thin metal wire from the key, and inserted it into something called a Leyden jar, a container for storing electrical charge.

Franklin's idea was to fly the kite into the storm-clouds and conduct electricity down the string. Later, when lightning struck the kite, Franklin moved his hand towards the key. Guess what happened? A spark formed, and Franklin felt a shock. But luckily for Franklin, he was standing on an insulator, keeping dry under a

roof, to avoid the danger of electric shock.

However, with this dangerous experiment, it was proved that lightning was electrical in nature.

Why is it said that electricity can be found in some fishes?

Electric charge is something that is seen everywhere in the Universe- even inside living things. Some fishes, for instance, have a surprising amount of electricity in them- like the electric eel.

Lightning Facts

The fear of lightning is commonly known as astraphobia, something which many of us have. The science of lightning is called fulminology.

Eels are freshwater predators found in the shallow, muddy areas of the Amazon and Orinoco rivers in South America. They often live in stagnant waters.

They possess enormous amounts of electricity that can possibly knock off a large horse, or even kill humans. It is said that the electric discharge from eels can be stronger than 500 volts. They are also known to have

Electric Eel

around 6000 cells called electroplaques that can produce electricity. Since eels have very poor eyesight, they emit weak electric signals for navigation to find a mate or prey. But when they spot a prey, strong shocks are given to stun them.

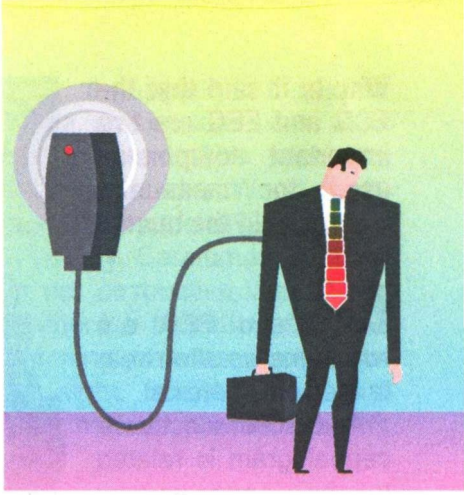
Other than eels, many fishes including sharks, lampreys, and catfishes have the ability to generate electric fields around them.

Why is it said that our body has electricity in it?

Just like the curious case of electric eels, the human body too produces electric signals. Did you know that? Well, everything that we do is made possible and controlled by these signals running all through our body.

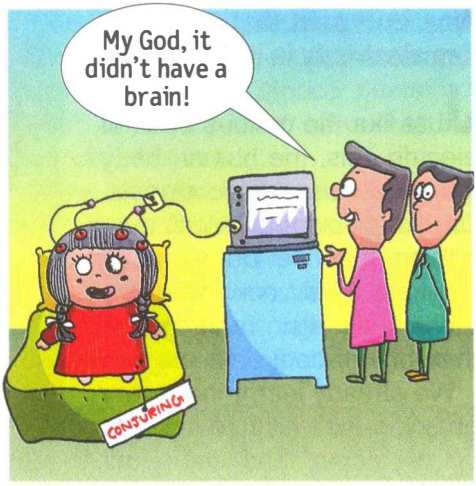
We already learnt that every object in the universe is made up of atoms, and so is our body. The flow of electrons in it is what we call electricity.

Let's take an example. When the brain orders our hand to hold a doorknob, or touch a book, there is electricity carrying messages from one point to another. But unlike an electric circuit, these electrons in our body are not travelling along a wire. Instead, the electric charge jumps from one cell to another in a very fast manner until it reaches its destination. In short, everything in the human body depends on electrical signals. Hence, a breakdown in the system can have serious impacts, including creating heart problems, and even strokes.



But since there is so much of electric charge jumping around in the body, do not think of it as a power house! Scientists hold that the human body can generate only 10 to 100 millivolts of electric charge. Quite strange, isn't it?

Why is it said that the ECG and EEG are two important equipments used for measuring electricity in the human body?



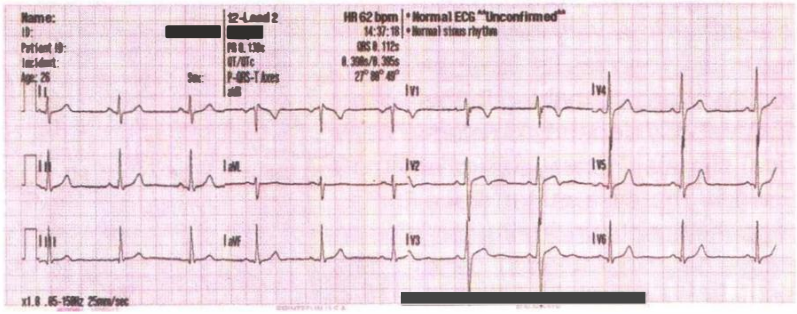
ECG and EEG are two terms we often hear in medical contexts.

An EEG or electroencephalogram is related to one's brain, and an ECG or electrocardiogram, to one's heart.

An EEG is a tool for measuring the brain's electrical activities. It is a test to check the patterns and location of electrical activities happening in the brain. Small metal discs with wires are stuck to our head to send signals to a computer. As the test goes on, the brain's electrical activity over that period gets recorded. Through this test, doctors can confirm if the person has any problems related to brain activities.

Electrocardiography on the other hand, is the process of recording electrical activity in one's heart over a period of

Electrocardiogram



time. For this test, electrodes or metal tabs are fixed to the skin- on the shoulders, chest, wrists and ankles. As the test begins, the electrodes detect tiny electrical changes on the skin that arise from the heart muscle's functioning, due to the heartbeat.

Through the electrocardiogram, the doctor gets to know more about the heart and its health.

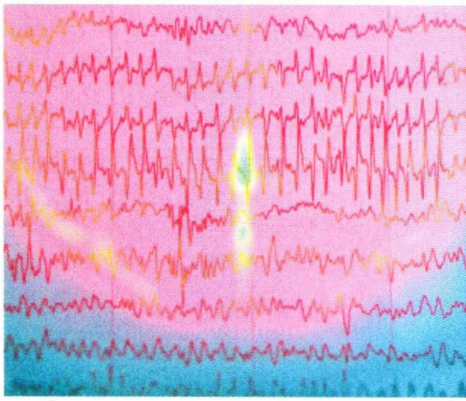
Why is Catatumbo lightning regarded as a strange phenomenon?

Lightning is not always a scary phenomenon. At least for the people in Venezuela, it isn't. This is because of the Catatumbo lightning, or the everlasting storm that they have almost everyday!

Technically, Catatumbo lightning, is an atmospheric phenomenon that happens in Northern Venezuela, where the river Catatumbo meets with Lake Maracaibo.

The peculiarity of this lightning is that it appears 260 nights a year, 10 hours per day, and up to 280 times per hour. It happens in the same place, and in clear skies, without a sound. This spot was thus declared a World Heritage Site by the UNESCO.

Luckily, Catatumbo lightning is not destructive like others. Rather it is helpful. Catatumbo lightning provides a spectacular sight. Scientists say that this natural phenomenon is



EEG

responsible for about 15 per cent of ozone production on Earth. Hence, the native people are very proud of it.

Although the reasons behind Catatumbo lightning are still debated, some experts believe it could be a result of methane from Lake Maracaibo.

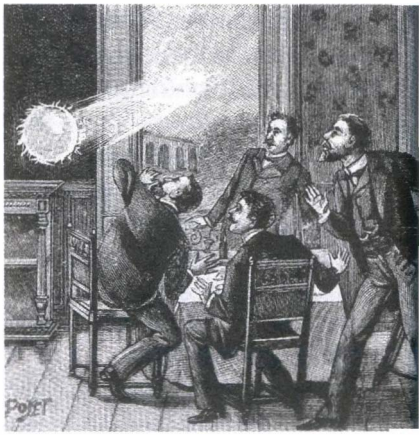
Why is ball lightning a strange electrical phenomenon in nature?

Ball lightning is an unexplained natural phenomenon that happens very rarely. It appears as a glowing ball during thunderstorms, following a lightning strike. It is said that these fireballs shine too brightly, and can be white, blue, yellow, orange, or red in colour. They vary in size and form; from that of a pea, to the size of a small bus.

Accounts of ball lightning have been recorded for the past few centuries. According to witnesses, these fireballs move in an unpredictable and fast manner, followed by smoke that forms spirals around them. Believe it or not, they can even enter buildings through doorways or windows, travel down corridors, and even navigate their way to certain points. They make hissing noises and sometimes, loud ones too. And all of a sudden, they disappear.

The reason behind the formation of ball lightning is unknown, and there are many

theories talking about the same. Even though there are many explanations for this phenomenon, none is accepted widely.



Sighting of Ball Lightning

STAR FACT

Greek Philosopher

Thales of Miletus is known to be the first person to conduct an experiment on electricity obtained by rubbing pieces of amber. He did this around 600 BC.

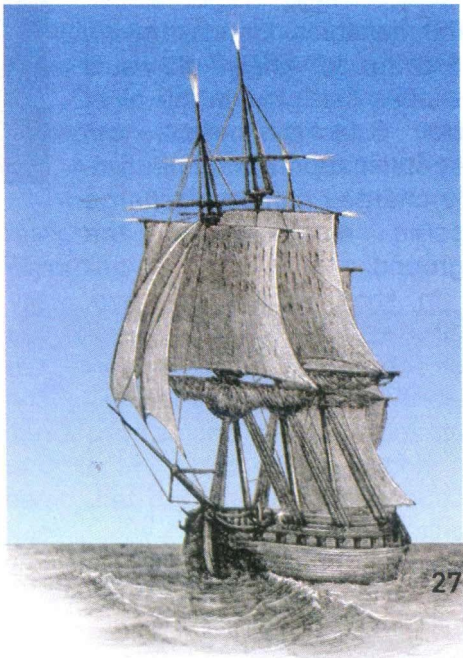
What is St. Elmo's fire?

The first account of St. Elmo's fire surfaced a few centuries ago, when sailors spotted a bright glow around their ships during thunderstorms. They believed it was something supernatural, and this belief continued to be so until scientists came up with their findings.

In fact, St. Elmo's fire is a phenomenon that is similar to lightning. It is a form of plasma caused by potential difference in atmosphere. Appearing like fire, the spectacle of St. Elmo's fire is seen mainly on tall and pointed structures like lightning rods,chimneys, aircraft wings etc. The glow comes along with a sound, because of which it is often confused with ball lightning.

Let's put it clearly with the same example of a ship. There is a difference of voltage in the atmosphere and the sea. This causes the ionization of gases surrounding the ship's masts, which in turn, results in a glow. This is what the sailors mistook as a miracle during thunderstorms.

St. Elmo's Fire



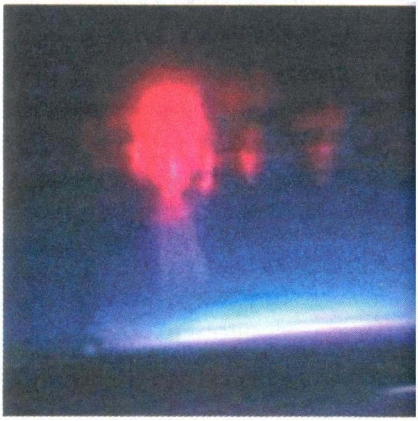
Why are sprites another strange electrical phenomena in nature?

Sprites are a natural phenomena that is related to electricity. They occur above thunderstorm clouds, giving rise to a variety of visual shapes that glow in the night sky. Scientists believe that sprites happen when neutrally charged clouds discharge some electricity to the ground.

In short, sprites are rare, large scale electrical discharges, occurring above thunderstorm clouds that appear as attractive visuals. Sprites have a reddish-orange colour in the upper region and bluish tendrils that hang below.

In most cases, sprites are witnessed by those in flight above storms. But since they appear for a very short time, the spectacle is often missed!

This phenomenon is known to have been occurring for centuries- it's just that no one could really record it. In July 1989, scientists at the University of Minnesota accidentally caught a sprite on camera. Years later, on April 30th, 2012 some astronauts captured a red flash of sprite, which was then used by researchers and people across the world, to study and research.



Colour Image of a Sprite

Why is an aurora considered to be the most fantastic electrical phenomenon on Earth?

An aurora is a display of coloured lights that occur naturally in the night sky. It is mainly seen in high latitude regions like the Arctic and the Antarctic.

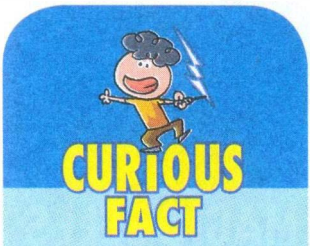
When they happen in the northern latitude, the effect is also called the Northern Lights, or Aurora Borealis. When it occurs in the southern latitude, it is referred to as the Southern Lights, or Aurora Australis.

Scientists and witnesses say that auroras mostly appear like curtains that extend in the east-west direction. They also happen to be the brightest, and the most distinctive kind.

Depending on the altitude, they shine in different colours, including blue, violet, red, bright green, ruby red etc.

Reasons behind the formation of auroras are still debated. According to one of the theories, the effect is caused by charged particles from the sun that interact with the Earth's atmosphere.

Many myths and legends are also built around the presence of auroras.



First Four

The sewing machine, fan, kettle, and toaster were the first four domestic items to be powered by electricity.

Aurora

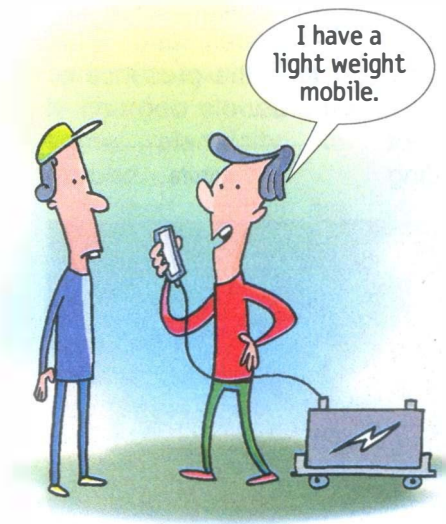
MAGIC CELLS

Why is it said that a battery is the most popular source of electricity?

A battery is a device that stores electricity in chemical form inside a closed-energy system.

Long before the invention of electrical generators and grids batteries proved to be the main source of electricity, and still continue to serve this purpose.

There are batteries in different shapes. Some are very small, like the ones used in wristwatches, or smart phones, and some are as big as those used in cars and trucks. At the extreme, there are huge battery banks that are the size of rooms.



All batteries have three parts- an anode (the negative side), a cathode (positive side) and an electrolyte, a liquid or gel that contains electrically charged particles called ions.

When connected to an external circuit, the ions interact with the other two, and a chemical reaction takes place inside the battery.

This reaction results in the generation of electric current. This is how batteries function

and provide electric power to all appliances in our house including mobile phones, laptops, flashlights etc.

Why is it said that there are two types of batteries?

Batteries can be broadly divided into two- primary and secondary.

Primary batteries are single-use batteries- that is, they can be used only once. After that, they should be discarded. They cannot be recharged. Quite a few non-rechargeable batteries are used in our daily life. This includes batteries used in toys, radios, remote controls, flashlights, clocks etc.

Those batteries that can be recharged and reused are called secondary batteries. Through electric current, these batteries can be recharged.

Secondary batteries can be seen in many devices including cellphones, MP3 players etc.

Yet another example can be seen in cars and trucks. Did you know that there is a lead-acid battery that works every time we start a car? This is how the car gets energy to run the lights and radio when the engine is not running. The battery in the car is recharged while we drive.

The Only One!

Iceland is the only country in the world where electricity is produced entirely by renewable sources.

Besides lead-acid, there are other batteries that can be recharged. This includes the nickel-cadmium battery, lithium-ion battery, nickel-metal hydride batteries etc.

Why is it said that the history of the battery is interesting?

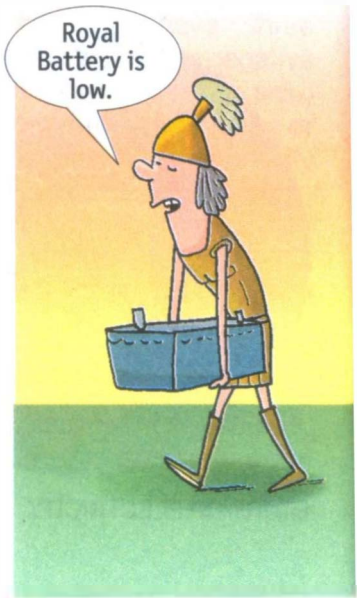
Batteries are devices that have been helping mankind for a long time. But nobody knows exactly when they were invented.

An account of the earliest battery came in 1938 from Baghdad. The story goes that while constructing a railway line in the city, workers uncovered a pre-historic battery. Experts said that the battery belonged to the Parthian Empire, and was at least 2000 years old!

Luigi Galvani, in 1786, was conducting an experiment when he accidentally touched a dead frog's legs with two different metals. Suddenly the muscles of its legs contracted. He thought it was because of 'animal electricity'. But his friend and fellow scientist Alessandro Volta didn't agree. He guessed that the same effect would be produced if cardboard was soaked in salt water, instead of a frog's leg. So, he stacked copper and zinc discs, separated by a cloth, and soaked them in salt water. He connected wires to either end of the stack.

Luigi Galvani

To his surprise, it produced stable current. Thus in 1800, Volta



CURIOUS FACT

Nickel Cadmium in Batteries

It is said that a nickel-cadmium rechargeable cell phone battery is capable of polluting 6,00,000 litres of water. That is, three such batteries can pollute an Olympic pool!

invented the 'voltaic pile', the first true battery that produced continuous and stable current. This is believed to have laid the foundation for the modern battery.

Which is the first practical-purpose battery?

The Daniell cell is perhaps the first practical purpose battery ever. It was an electrochemical cell developed by the English chemist John Daniell in 1836. The cell offered a long-lasting source of power.

Let's see how the cell works. Daniell cell, consist of a copper pot filled with a copper sulfate solution, in which was immersed an unglazed earthenware container filled with sulfuric acid and a zinc electrode. The earthenware barrier which is porous, allows ions to pass through, but keeps the solutions from mixing.

This cell produces current like a voltaic cell does, but with more efficiency. It soon became the industry standard for use. A voltage of over one volt is produced by a Daniell cell. To get a little more voltage, one has to increase the concentration of the solution in which the electrodes are dipped.

Daniell Cell

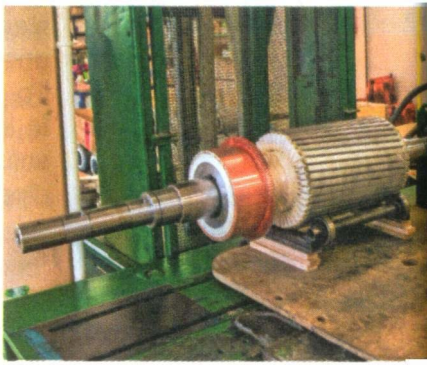
ELECTROMAGNETISM

What is meant by electromagnetism?

Electromagnetism is a basic force of nature. It is the creation of a magnetic field from the movement of electrical charges.

The basic characteristics of this force can be best defined through the example of a copper wire. When electric current is allowed to pass through the wire, it can attract, or magnetize pieces of iron or steel near it. That is, the electromagnetic force causes the attraction, as well as repulsion, of electrically charged particles.

There are two basic concepts behind electromagnetism. The first one is that, any moving charge produces a magnetic field because of its movement. The second one is that, a moving magnetic field



An Electric Motor

can cause current to flow into a conducting loop. This means, if there is a moving bar magnet near a coil of wire that is connected to a meter, it can detect the current flow.

Why is the history of the electromagnetic theory interesting?

The history of electromagnetism cannot be complete without a few names. Let's take a look at a few of them.

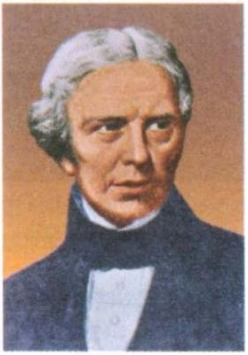
In 1820, Hans Christian Orsted, a professor at the University of Copenhagen, arranged an experiment for his students. He wanted to explain the heating of a wire by an electric current, and his experiments on magnetic property. For this, he used a compass needle mounted on a wooden stand. Suddenly, he noticed that every time the electric current was switched on, the compass needle moved. Orsted was surprised, and kept working on this for months to study how it happened. However, he was not successful.

But this experiment was taken further by another physicist in France named Andre-Marie Ampere. Through his study, he found out that wires with parallel currents attract each other, whereas those with anti-parallel current repel. He concluded that electricity can be governed by two sets of forces- electric and magnetic.

A few years later, Michael Faraday and Joseph Henry independently found out that it is possible to produce current

Hans Christian Orsted

Andre-Marie Ampere



Michael Faraday

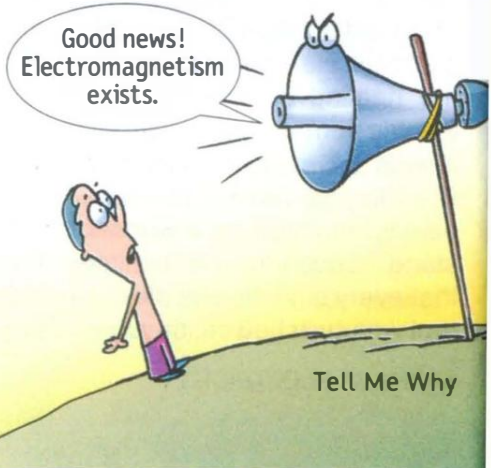
A Maglev Train

in a conductor by changing the magnetic field around it. This theory helped in laying the foundation of modern day electricity.

However, earlier electricity and magnetism were seen as two different properties. It was in 1865 that James Maxwell published his work 'A Dynamical Theory of the Electromagnetic Field', demonstrating the connection between the two forces.

Why is it said that many of the phenomena that we witness in our daily life can explained by electro magnetic force?

Electromagnetism is a phenomenon that works behind almost all forces on Earth. Perhaps the only



CURIOUS FACT

Maglev

Magnetic levitation or Maglev trains function on very strong electromagnets that carry the train on a cushion of magnetic repulsion.

exception is gravity. Its influence is such that experts believe modern life is run through the electromagnetic phenomenon. Let's try to understand what this means.

Take the case of an electric fan. Its motor works on the principle of electromagnetic induction, which keeps it rotating on and on. This in turn, makes the blade hub of the fan to rotate, blowing air. Another example is that of a loud speaker. It is the electromagnetic force that is responsible for the movement of the coil inside. This in turn, results in the production of sound that can be heard over a long distance.

In the same way, almost all appliances that we use in our daily life, including motors, gadgets, TV, radio, computers, work on the principle of electromagnetism.

In short, all forces involving interaction between atoms can be explained in terms of electromagnetism that occurs between the electrically charged atomic nuclei, and electrons of the atoms.

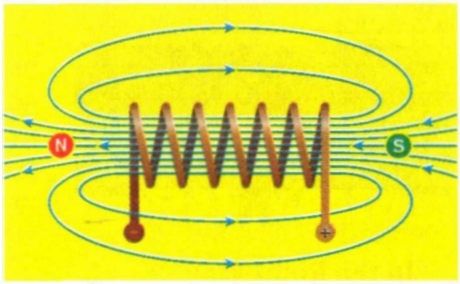


Diagram of the Magnetic field created by Electricity

What is an electromagnet?

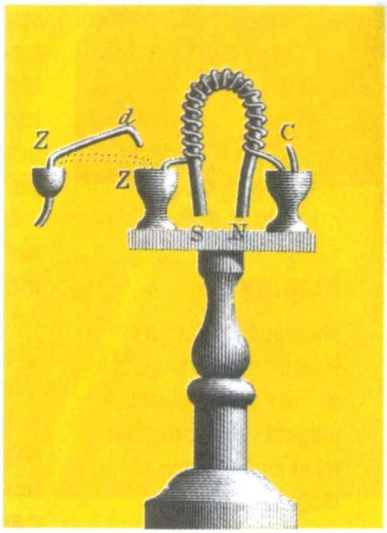
An electromagnet is a device that can create a magnetic field if electricity is allowed to pass through it.

We can understand it better by

comparing it with an ordinary magnet. In normal magnets, magnetic power is always present. But in electromagnets, the magnetic power or field, depends on electricity. It can be turned on or off, using a switch. Likewise, the strength of these electromagnets can also be increased by increasing the amount of electric current.

There are different parts for an electromagnet. It consists of a coil of wire, made mainly of copper, and a piece of metal. The wire should be wrapped around the metal piece. When electric current is allowed to flow into the wire, a magnetic field is created around the coiled wire, and the metal gets magnetised. This is how an electromagnet is created.

Today, almost all equipment that we use, have electromagnets in them.



William Sturgeon's Electromagnet

STAR FACT
In the Right Way
According to Fleming's right-hand rule, if one holds his right thumb, first finger and middle finger at 90°to each other, the middle finger will indicate the direction of the induced current.

Why is it said that the introduction of electromagnets was interesting?

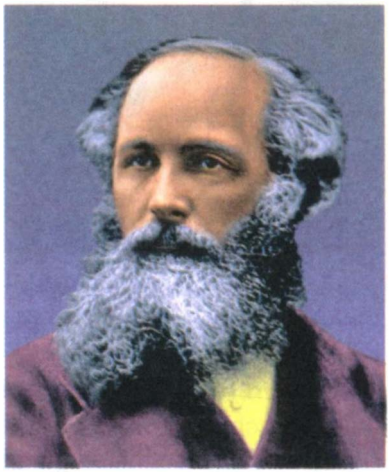
The first recorded discovery about the relation between

electricity and magnetism was made by Hans Christian Orsted in 1820.

During an experiment, he noticed that the needle on his compass pointed to a different direction, when a battery near it was turned on.

In 1824, William Sturgeon invented an electromagnet. It was made of a horseshoe-shaped piece of iron, wrapped with copper wire. He found out that when current was passed through the wire, it attracted the pieces of iron, and when the electric flow stopped, the magnetisation ended too.

By the 1830s, the US scientist Joseph Henry improved the design of the electromagnet. He used an insulated wire, and placed thousands of turns of wire on a single core. This made a big change! With this attempt, electromagnets gained more popularity.



James Clerk Maxwell

What is meant by electromagnetic radiation?

There are different waves of light and energy that move around us.

They come in the form of heat in the atmosphere, or radiation from space, or in any other form. These energy waves are commonly known

Heinrich Hertz

as electromagnetic radiation. They have electric, as well as magnetic characteristics.

The scientific definition given to this by experts goes as follows - the energy that is propagated through free space or a material medium in the form of electromagnetic radiation.

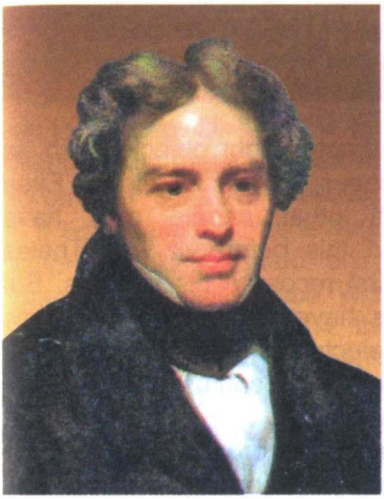
Other than visible light, electromagnetic radiation includes radio waves, microwaves, infrared waves, ultraviolet rays X-rays, and gamma rays. They are classified on the basis of their frequencies or wavelengths. The fact that the electromagnetic radiations are related to electromagnetism was put forward by a few scientists in the past. The existence of electromagnetic waves was first predicted by the Scottish physicist James Clerk Maxwell. In his electromagnetic theory that he put forth in 1864, he said that light is an electromagnetic disturbance in the form of waves.

A few years later, German physicist Heinrich Hertz applied Maxwell's theories to prove the existence of electromagnetic waves.

What is electromagnetic induction?

In its simplest terms, electromagnetic induction can be defined as the process where a conductor placed in a changing magnetic field causes the production of voltage across the conductor. This, in turn, causes or 'induces' an electric current.

Many electrical devices that we see daily work on the principle of electromagnetic induction. A common use of this can be seen in electrical generators, transformers, induction



Michael Faraday

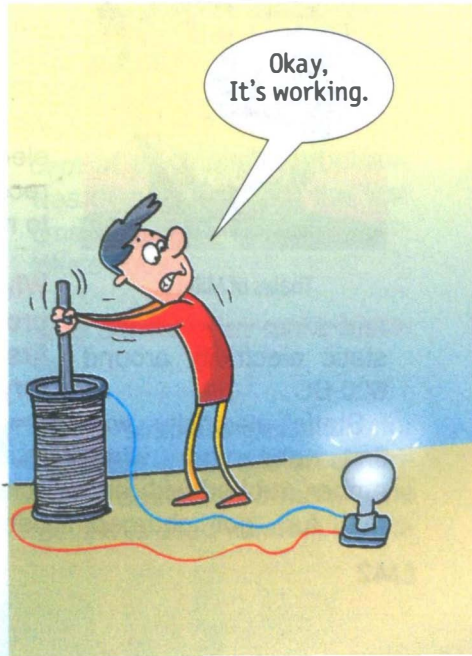
cookers, musical instruments etc. The concept of electromagnetic induction was put forth in the early 1830s by the English physicist Michael Faraday.

He conducted many experiments to study the idea. In one of it, he used a coil of wire, a permanent magnet and a device to detect voltage in the wire. When Faraday passed the magnet through the coil of wire, he saw there was a voltage induced, and therefore current too. But it soon disappeared when the magnet stopped moving. From this, Faraday made a few observations. The most important one was that the induced voltage is the result of a changing magnetic field.

In other words, Faraday discovered a way to produce electrical current by using the force of a magnetic field.

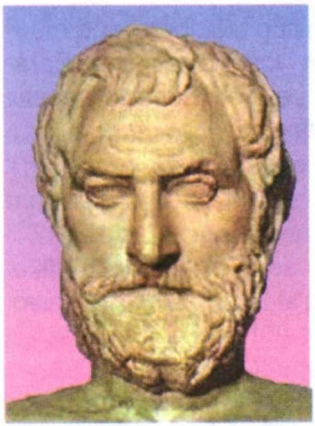
The voltage induced is known as the electromotive force, or emf.

Faraday's findings led to a law linking electricity and magnetism known as the Faraday's Law of Electromagnetic Induction.



Why is it said that Thales of Miletus played a major role in the history of electricity?

Thales of Miletus is an important figure in the history of electricity. It is said that he discovered static electricity around 600 BC.



Thales of Miletus

Static electricity was first observed when amber, rubbed with animal fur, got charged, and attracted light objects such as dry leaves, or bits of straw. Even though other people may have noticed this before, it was Thales who first recorded his findings. But Thales have never identified it as static electricity. At that time magnetism was also confused with static electricity.

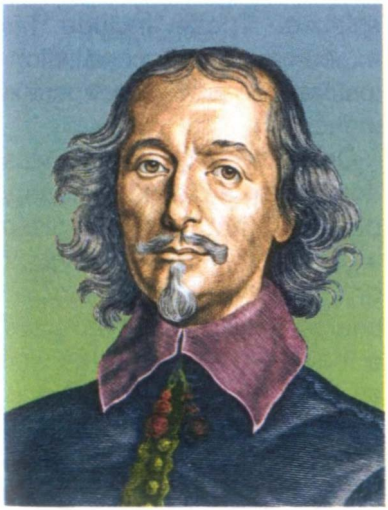
Later, it was proved that the force that work between amber and animal fur is nothing but static electricity. Thales' role was remarkable because he was the first to record his findings regarding static electricty. Thales was born in the city of Miletus around the mid 620 BC. He was a philosopher, and astronomer and the one who conducted the earliest studies in electricity. Thales' findings were recorded but none of them survived to modern times.

Why is it said that the machine which produced static electricity for the first time was a turning point in history?

Otto von Guericke was a German scientist, and inventor who lived between 1602 and 1686.

He is credited to have made many inventions at a time when there were not many resources to refer to. One of it is the electrostatic generator, known to be the first one ever made.

It was described as a huge sulphur ball, mounted on a pole inside a glass globe. With the help of a hand crank, the ball was rotated. As a result, the ball rubbed against a pad, generating sparks. This was static electricity, a phenomenon which they could not identify then. But the device became famous, and was used for later experiments with electricity.



Otto von Guericke

In 1672, Guericke found out that electricity produced through his earlier experiment could cause the surface of the sulphur ball to glow. The concept of electrostatic repulsion was demonstrated for the first time in history through Guericke's book.

Why did the relay make history?

The simplest definition for the relay is that it is an electrically operated switch. The device is used where it is nec-

essary to control a circuit by a low-power signal or where a number of circuits have to be controlled by one signal.

Relays are controlled by electric current, magnetism or temperature. There are two types of relays- electromechanical and solid state. In the former, contacts are opened and closed using a magnetic force. With solid state relays, switching is done electronically.

Joseph Henry

Electromechanical relays are general purpose relays. They are more common because they have lower cost, and can switch from AC or DC with equal ease.

The relay was invented in 1835 by Joseph Henry. He created it in order to improve his version of the electrical telegraph.

Relays are used for many purposes. Their application can be seen in digital computers, telephone exchanges, and automation systems.

Why is it said that Stephen Gray played a major role in the history of electricity?

Stephen Gray was an English astronomer who made significant contributions to science. These include his experiments with conduction, insulation, and electrostatic induction.

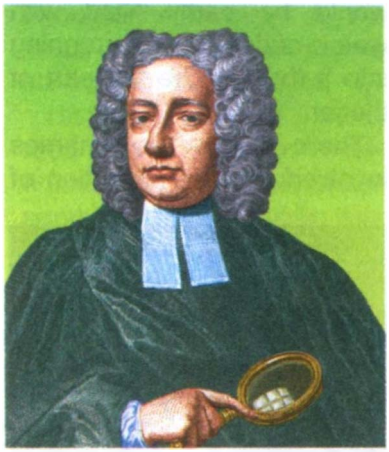
One of his experiments was done using a glass tube. Gray observed that when the glass was rubbed with a dry hand or dry paper, it obtained electric charge. As a result, it attracted a feather to the glass, as well as the cork with which it was closed. The cork was in fact, used to keep the dust out when not in use.

From the experiment, Gray concluded that the 'attractive

virtue' is passed from the tube to the cork.

To clear his doubts, Gray proceeded with a similar experiment. This time, he attached an ivory ball to a piece of wood, and inserted the other end of the wood into the cork. Once it was done, he confirmed that attraction and repulsion passed to the ball, that too stronger than that on the cork.

Gray observed that substances like silk do not conduct electricity. And that Earth was somehow responsible for conducting electric charge away from the body.



Stephen Gray

For his electrical experiments , Stephen Gray received the first Copley Medal instituted by the Royal Society, in 1731. However most of his works went unacknowledged, and he died as a poor man.

Why was the introduction of Leyden jars a milestone in history?

A Leyden jar was the first device that could store electric charge. It was a glass jar with metal foil wrapped to its inside and outside surfaces. The jar

would be partly filled with water, and had a wire running into it through the top part of the jar.

There are two names involved with the invention of the jar. One is Ewald G. von Kleist, a German inventor who is said to have accidentally created it in 1745. The other is Pieter van Musschenbroek of Leyden, Holland, who 'discovered' the same thing in 1746. The latter invention spread through the world quickly, and thus Pieter gained more popularity for the invention.

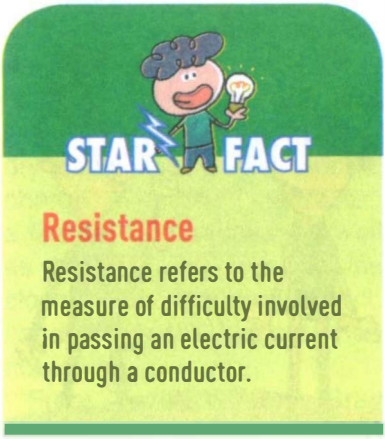
Benjamin Franklin

At first, it was thought that the electric charge was stored in the water inside the jar. In the 1700s, Benjamin Franklin studied much about this and proved that charge was stored in the glass. Hence, the later versions of Leyden jars had just metal foil wrapped inside and outside the glass.

Technically, a Leyden jar is the prototype of the modern day capacitor which are used in almost all electronic equipment today.

Why was the invention of the lightning rod a major breakthrough?

Benjamin Franklin invented the lightning rod in 1749. A lightning rod is a metal rod


STAR FACT
Resistance
Resistance refers to the measure of difficulty involved in passing an electric current through a conductor.

A Lightning Rod

mounted on top of elevated structures like a building, tree, ship etc.

It is electrically bonded with a wire with the ground or 'earth' through an electrode. Such an object protect a structure while lightning strikes. The idea behind it is that when lightning hits the building or tree, it will strike the rod.

As a result, the electric power from lightning will be conducted to the ground through the wire, instead of passing through the building or tree. Thus, the structure can be saved from electrocution.

Historians say that lightning rods were used in ancient times, and were particularly seen in the Sri Lankan kingdom of Anuradhapura, thousands of years ago. However, in the modern age, it was Benjamin Franklin who introduced the idea to the world. His aim was to create a tool that could save people from the dangers of the natural phenomenon. Through a series of experiments including the famous one using kite, he created the 'Franklin rod'.

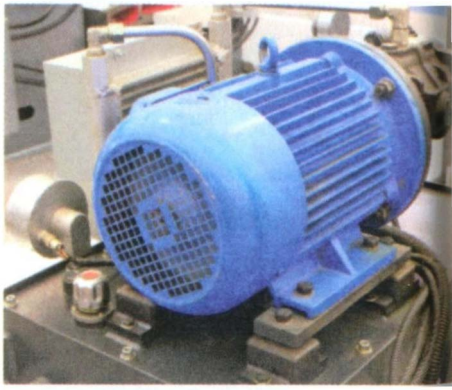
Moritz Jacobi

Why was the introduction of the electric motor important?

An electric motor is a device that converts electrical energy into mechanical energy. It works on the principle of electromagnetism.

The first electrical motor is known to have been invented by a Scottish monk Andrew Gordon, in the 1740s. His motor was a simple electrostatic device.

Almost a century later, British scientist Michael Faraday explained the conversion of electrical energy into mechanical energy by means of electromagnetism. The motor he created through the experiments was primitive, but it paved the way for later inventions. In 1822, British physicist Peter Barlow invented the first device to be powered by electromagnetism- known as Barlow's Wheel.



An Electric Motor

A decade later, British scientist William Sturgeon developed the first machine to be run on direct current. A few years after that, inventor Moritz Jacobi created the first real rotating electric motor that developed a remarkable mechanical output power.

Frank Julian Sprague was the first to introduce a constant speed electric motor.

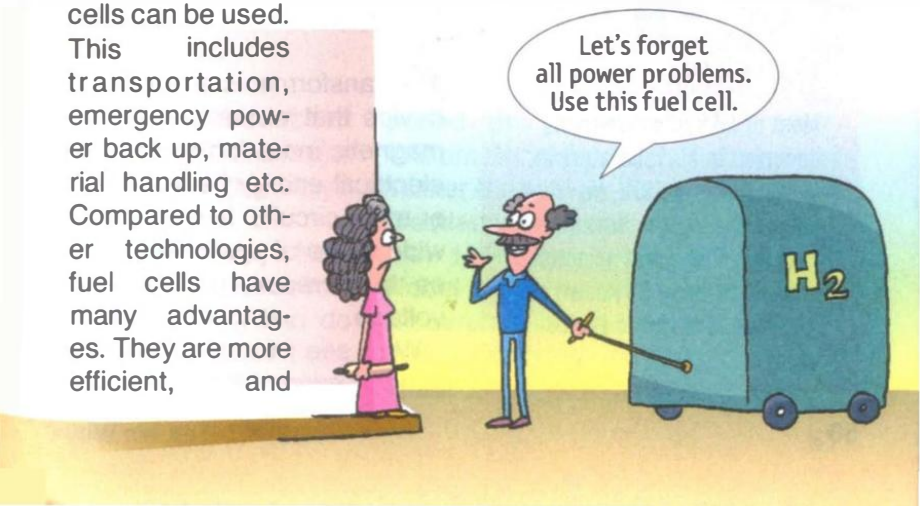
All these have together contributed to the advancement of engineering technology in the world.

William Grove

Why was the introduction of the fuel cell a milestone?

Fuel cells are devices that generate electric current through chemical reactions. To put it better, a fuel cell uses chemical energy of hydrogen (or another fuel) to produce electricity in a clean and efficient manner. Its only products are electricity, heat, and water, and hence it is clean.

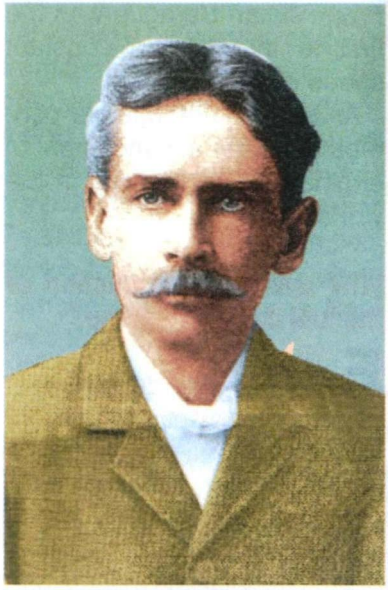
There are a wide range of applications for which fuel cells can be used. This includes transportation, emergency power back up, material handling etc. Compared to other technologies, fuel cells have many advantages. They are more efficient, and have lower emissions. That is, they do not emit dangerous substances like carbon dioxide or air pollutants, as their only products are water and heat. Yet another advantage is that



fuel cells operate in a silent manner.

The history of fuel cells began with the Welsh physicist Sir William Grove. In 1839, he demonstrated the first crude fuel cells. Although many people have tried to work on the concept of converting chemical energy into electric power, most of them were unsuccessful due to lack of resources.

The first successful fuel cell was developed by the British engineer Francis Bacon in 1932, using hydrogen, oxygen, an alkaline electrolyte and nickel electrodes.



William Stanley

The Wizard

Most of Edison's inventions occurred in his laboratory in Menlo Park. In 1878, he named the lab the 'Invention Factory'. This great scientist himself came to be known as 'the wizard of Menlo Park'.

Why is it said that the invention of the transformer was a turning point?

A transformer is an electrical device that works on electromagnetic induction to transfer electrical energy between two or more circuits. It is used in a wide range of power appliances to increase, or decrease voltage.

We see transformers in almost every city. They are

used to convert high-voltage electricity from incoming power lines, to lower-voltages.

The first known transformer was developed in the 1880s. Since then the device has played a key role in transmission of power. There are mainly three names involved with the invention of transformers-Otto Blathy, Miksa Deri and Karoly Zipernowsky. They are known to have designed the first transformer in the early 1880s. The first reliable commercial transformer was built in 1885 by William Stanley. Since then the device has played a key role in the transmission of power.

Why is the introduction of the transistor a major turning point in history?

To put it simply, a transistor is an electronic component that can do two different jobs. It can act as an amplifier or a switch, depending on the need.

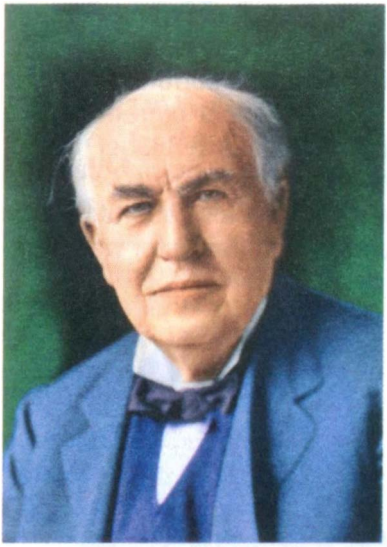
As an amplifier, a transistor does the job of boosting current. That is, it takes in a tiny input current at one end and produces a bigger output current at the other end.

It was at the Bell Laboratories in New Jersey that transistor was demonstrated for the first time. That happened on December 23rd, 1947. William Shockley, John Bardeen and Walter Brattain are the three persons credited with its invention.

microelectronics group
A replica of the first transistor, invented at Bell Labs, December 23, 1947
Lucent Technologies
50 Years and Counting...

A Replica of the First Transistor

In 1956, they were awarded the Nobel Prize in Physics "for their researches on semiconductors and their discovery of the transistor effect".



Thomas Alva Edison

Why is the Edison effect an important milestone in history?

In one of his experiments, Thomas Alva Edison discovered that electrons can flow from one metal conductor to another, through a vacuum. This discovery was later named as the Edison Effect.

Sometime in the early 1880s, Edison and his team were working to find a light bulb filament. Their carbonised bamboo filament did well, but even so, carbon deposits were seen inside the bulb after hours. That was when he noticed that the carbon came from the end of the filament which was attached to the power supply. It looked as though it was flying through a vacuum onto the walls!

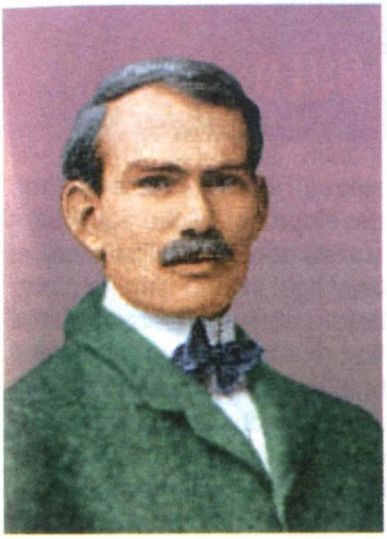
Edison realised that there was electric charge flowing not just through the filament, but through the evacuated bulb as well.

Although Edison was right about the flow, he could not find the reason behind it. He moved on to other experiments.

Later, it was proved that Edison, with his experiment, discovered the basis of the vacuum tube. And the modified light bulbs were later used to control the flow of electrons through vacuum.

Why is it said that the amplifier and triode changed the history of electricity?

An electronic amplifier is a tool that can amplify or increase the power, current, or voltage of a signal. It could be either a



Lee De Forest

separate piece of equipment, or an electrical circuit within another device, but in general, amplifiers are used in almost all electronic equipment that we see around. They are particularly used in wireless communications and broadcasting.

Before the amplifiers were introduced, mechanically coupled microphones were used to serve the purpose in telephone repeaters.

In 1906, the triode was invented. It was the first electronic device that could amplify signals. It is a fundamental form of vacuum tube developed by the American inventor Lee De Forest. He had only a little understanding of how the tube worked.

However, the discovery revolutionised electrical technology, and laid the foundation of electronics. It also made possible radio broadcasting, talking motion pictures, and countless other applications.

A Triode

INVENTION OF LIGHT BULB

Humphrey Davy

Why is it said that Humphrey Davy's contributions are unique?

The story of the invention of the electric bulb was very interesting. Even though many believe that it is Thomas Alva Edison who discovered the light bulb, it was not so. He played a major role in the development of the light bulb, and its popularity. The story of the light bulb begins long before Edison patented the first commercially successful bulb in 1879.

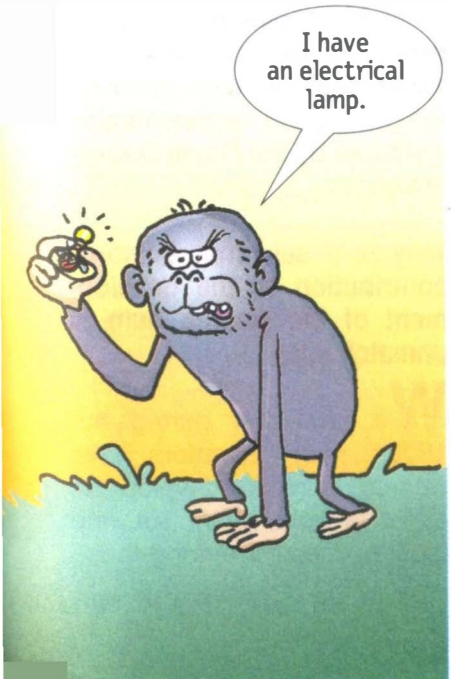
Alessandro Volta's invention of the battery in 1800, gave inspiration to many scientists. One among them was Humphrey Davy. He produced the world's first electric lamp by connecting voltaic piles to charcoal electrodes. It cannot be called an electric bulb as such. It was an electric arc lamp, and he introduced it in 1802. It was named so for the bright arc of light emitted between its two carbon rods. However, Davy's arc lamp wasn't a very practical source of lighting. It was much too bright for use in a home, and it burned quickly. But the principles behind this arc light were used throughout the 1800s, and many took inspiration from this invention.

Why is it said that William Staite and Warren de la Rue's contributions are remarkable?

Different kinds of electric lamps were invented by masters in the past.

The English inventor Humphrey Davy's electric arc lamp was one such creation that made great changes in the field of electricity and lighting.

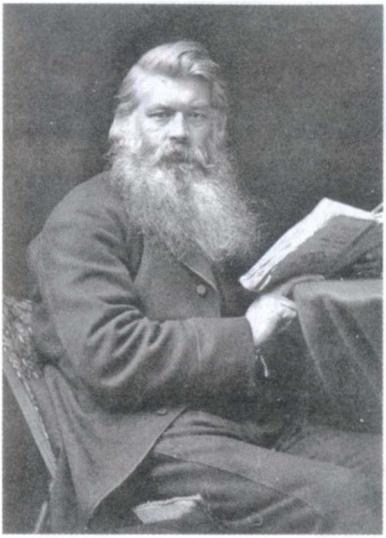
However, the arc lamps were not flawless. Their biggest disadvantage was that they were not fit for practical use. They emitted too much of light and also, burnt out quickly. Nevertheless, the principle of arc lamps was used till the 1900s by various inventors for developing electric lights and bulbs. Among them were Warren de la Rue and William Staite.



In 1840, the British scientist Rue developed a light bulb using coiled platinum filament instead of copper. Staite, on the other hand, had been working on increasing the longevity of conventional arc lamps. In 1848, he developed a clockwork mechanism. Through this, he was able to regulate the movement of the carbon rods used in the lamps that eroded very quickly.

First in the World

Joseph Swan's house has a historical importance. It was the first in the world to be lit by a light bulb, and also, by hydroelectric power.



Joseph Wilson Swan

Why is it said that Joseph Swan, along with his contemporaries, made a significant change in electric bulb?

Another person who made significant contributions to the making of the electric bulb is Sir Joseph Wilson Swan.

Swan was an English chemist. During the 1850s and 1860s, he conducted many experiments on bulbs using carbon filaments. Most of them failed, because the vacuum pumps used in those times were not good, so they couldn't remove enough air from the lamps. Besides, the lamp deposited a dark layer of soot in its inner surface. This obscured the light.

In 1878, Swan demonstrated an improved working lamp. It had a better vacuum, and carbonised thread as a filament. The method of processing was such that the bulb avoided early blackening. Soon after the demonstration, Swan was granted a UK patent. After that, light bulbs were installed in homes in England. In 1880, he received a US patent too.

For his contributions, Swan was knighted in 1904. The same year he also received the prestigious Hughes Medal, instituted by the Royal Society of London.

Why is it said that Edison's contribution to the development of the electric bulb is unmatchable?

We saw that during the 1800s, many inventors have worked hard to develop an effective light bulb. But, the most successful among these

Thomas Alva Edison

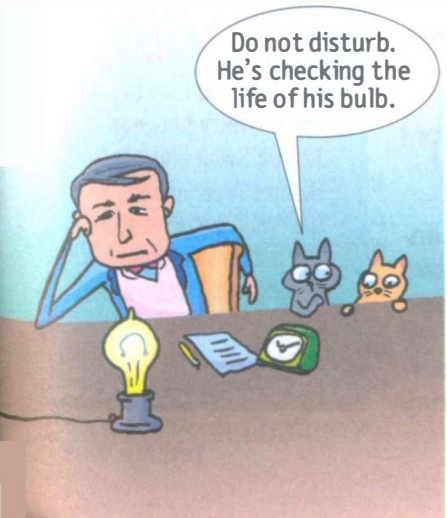
inventors was Thomas Alva Edison.

Edison's serious research into making a practical incandescent lamp began around 1878. He wanted to invent a safe, yet cheap electric light that could replace the earlier ones. Between 1878 and 1880, he conducted many experiments, with carbon filaments, platinum, and other metals. In 1879, he successfully tested a bulb with a carbon filament that lasted 13.5 hours.

The following year, Edison and his team discovered that a carbonised bamboo filament could last over 1200 hours. This marked the beginning of commercially made light bulbs in 1880.

As we know, this is just one of the many inventions made by Edison.

Thus, Edison's contributions remain unparalleled and, for his tireless work, he was rightfully described as one of the greatest inventors.



Who invented light bulbs with tungsten filaments that are widely used today?

Scientists and inventors have used a number of filaments for incandescent bulbs in the past. But today, the

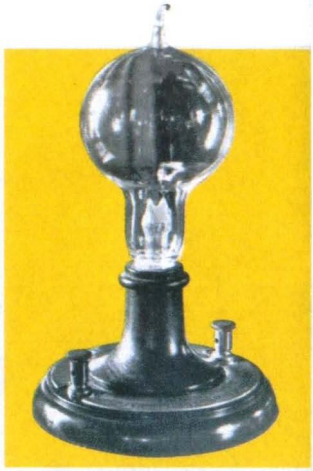
most popular one is the tungsten filament.

It was William David Coolidge, who developed a method to manufacture tungsten filaments in 1910.

The biggest advantage of tungsten was that it had a high melting point, and was able to withstand heat and corrosion. That is exactly what attracted inventors to it. Besides, using inert gases inside the bulb increased its luminescence.

As years passed, the element was used in other lamps too, including halogen, fluorescent, mercury vapour etc. Tungsten is perhaps the most durable type of filament used in bulbs even today.

It is said that Thomas Alva Edison himself knew that tungsten would prove to be the best choice for filaments. But in his day, the technology and machinery required to produce the wire in fine form was not available.



Edison's Bulb

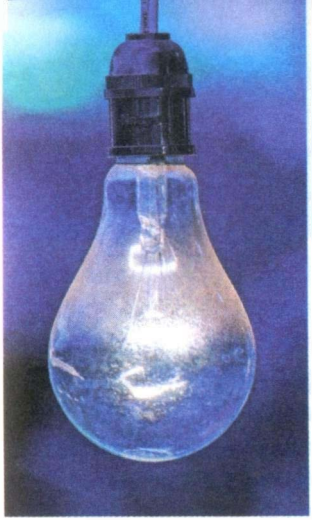
Enmity of equals

It is believed that there was a rivalry between Joseph Swan and Thomas Alva Edison. The two great inventors had not met or spoken to each other before the invention of the incandescent lamp.

How is a fluorescent lamp different from an incandescent lamp?

As you may already know, incandescent and fluorescent are two types of light bulbs commonly used for various lighting applications.

Incandescent light bulbs are older, but are still used in our houses. They



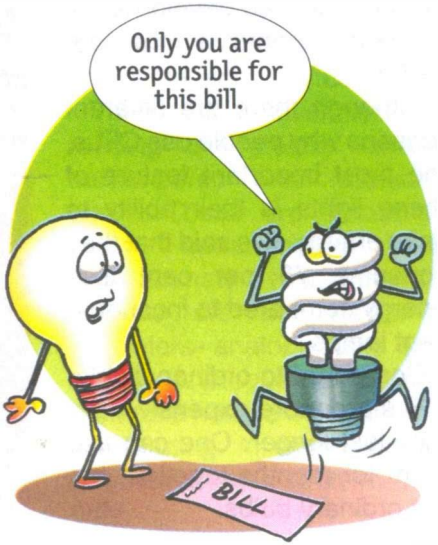
Incandescent Light Bulbs

come in the form of a glass sphere, with a very thin filament inside. It is the tungsten filament that we mostly use now, and it is surrounded by an inert gas. In these bulbs, light is produced by heating the metallic filament until it starts to emit light.

A fluorescent bulb is totally different. It is a glass tube coated with phosphorous, containing mercury vapour. When the gas inside is excited, these lamps produce light. Unlike incandescent lights, they come in different shapes and sizes.

There are many other differences between incandescent and fluorescent lights other than these. The former has a low efficiency, and short life. Fluorescent lamps have very high efficiency, longer life, and are also energy saving. They are said to last 10 to 20 times longer than an incandescent bulb.

However,many experts say that fluorescent lamps pose threat to health and environment. This is because of the mercury content in them. Also, fluorescent lamps are more expensive than the other type.



What makes compact fluorescent lamp an energy saving option?

A compact fluorescent light (CFL) bulb or lamp is a type of fluorescent lamp that is designed to replace incandescent lamps. They are known by different names- as compact fluorescent light, or energy-saving light, or as compact fluorescent tube. CFLs come in different shapes and forms, and are primarily known for their effectiveness and long life.

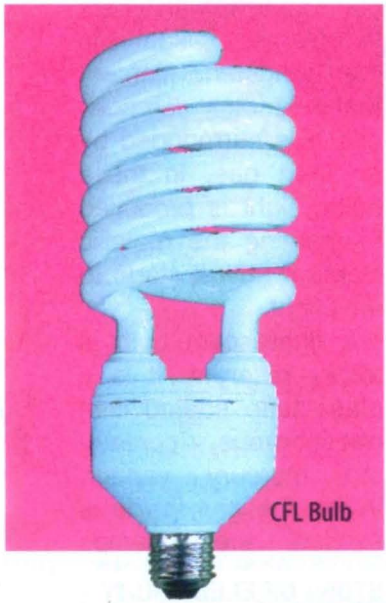
The modern, spiral shaped CFL bulb that we use today in our houses was developed by Edward Hammer in the late 1970s.

Although there are different reasons why people use CFLs, the most important feature of these lights is their ability to save energy. It is said that they consume 75 per cent less energy compared to incandescent lamps.

Compared to ordinary lights, CFLs are more expensive, but they last longer. One can use them for months together, but not ordinary bulbs.

Deep Inside

Huge electric currents are generated from the Earth's iron core that lies deep inside. These currents cause a magnetic field to be formed that extends to outer space, far beyond the Earth's surface.

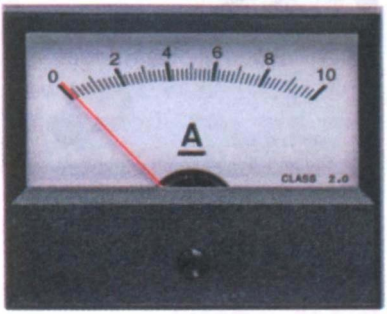


MEASURE IT RIGHT

Why is an ammeter important?

An ammeter is an instrument used to measure the flow of electric current in a circuit. It measures current in terms of amperes, which is the unit of current. The speed and force of a current can be measured using this instrument.

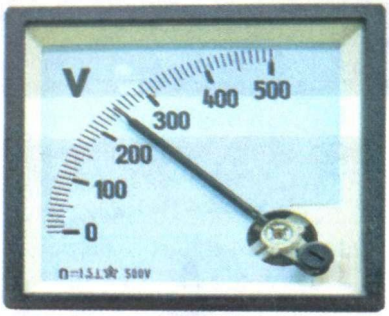
In the past, the instrument relied on the Earth's magnetic field to take the readings of current. But as technology improved, better ammeters were designed and developed. Ammeters are mostly used in science laboratories. Other than scientists, electricians also use this instrument, to check the electric circuit.



Ammeter

There are smaller units of reading to amperes, namely, milliamperes and microamperes. These are measured using milliammeters and microammeters respectively.

There are two types of ammeters- analogue and digital. In analogue ammeters, there is a needle that points to the reading. In digital ammeters, they are displayed digitally.



Voltmeter

Why is the voltmeter an important equipment?

A voltmeter is an instrument that measures the voltage between two points in an electric circuit. It can be connected to a circuit by joining its positive and negative wires to where the voltage is. With such an arrangement, the instrument is said to be parallel to the electrical circuit.

A voltmeter can be used for many purposes. For instance, to check whether there is any more electricity left in a battery.

In an analogue voltmeter, the pointer indicates the number of volts. In a digital voltmeter, the reading will be displayed digitally. There are also voltmeters that can be mounted on a transformer, and other huge devices.

Yet another variety is a voltmeter that use amplifiers in them. Such meters can measure very small, or tiny voltages of microvolts, or even less.

What is a galvanometer?

A galvanometer is a tool that measures the flow of electric charges through a wire. This basic device consists of a coil placed in a magnetic field. It can be used for detecting and

Etymology

The term galvanometer was derived from the name of the Italian electricity researcher Luigi Galvani, who discovered the principle of frog galvanoscope in 1791. He had found out that the legs of a dead frog would move if it received an electric current.

Digital Galvanometer

comparing small electric currents.

The idea of galvanometers are known to have developed from an observation made by Hans Orsted in 1820. He had found out that the needle of a magnetic compass deflects near a wire that has electric current passing through it. But it was Johann Schweigger who built the first sensitive galvanometer in the same year. Galvanometers, since then, came to commercial use.

A galvanometer can be used as an ammeter, as well as a voltmeter. By connecting a shunt in parallel to the coil, it acts an ammeter, and if the shunt is connected in series with the galvanometer coil, it becomes a voltmeter.

What is a multimeter?

A multimeter is an instrument that measures the voltage, current, and resistance of an electrical device. Also known as a VOM (Volt-Ohm-Milliammeter), they are very useful in providing field measurements or detecting faults with accuracy.

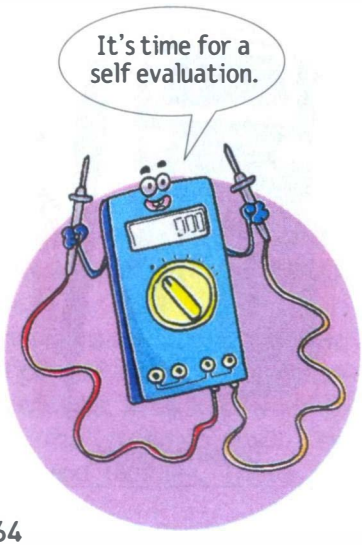
The first multimeter was invented by Donald Macadie, a British post office engineer who was unhappy with the need to carry separate instruments needed for the maintenance of telecommunication circuits. His invention was the instrument that could measure

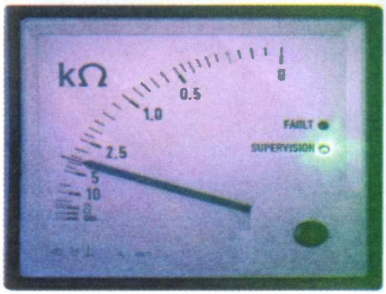
Digital Multimeter

amperes, volts and ohms, and was named the avometer.

The device is commonly used by electricians and other experts to troubleshoot problems on appliances, motors, circuits, power supplies and wiring systems. They could use the device on batteries, switches, power sources etc for measuring or diagnosing.

Multimeters can be analogue or digital. Analogue multimeters are cheaper, but their readings are not as accurate as the digital meters. Recent digital multimeters are advanced enough to measure extremely tiny differences or fluctuations.





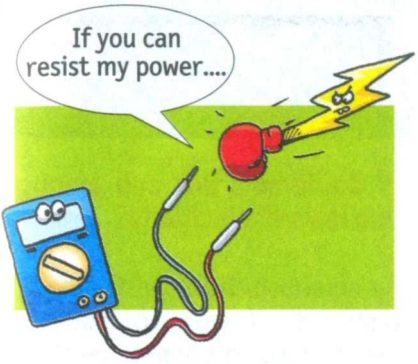
Ohmmeter

Why is the ohmmeter an important measuring equipment?

An ohmmeter is an electrical instrument used to measure resistance of a conductor. Resistance, as we have already seen, is the opposition offered by a substance to the current flow in the device. The unit of measurement for resistance is in ohms, hence the tool to measure it is called an ohmmeter.

One must know that every device has a resistance, large or small. Resistance in conductors increases with temperature, but decreases in the case of semiconductors.

Depending on the application, there are micro ohmmeters, milli ohmmeters, and



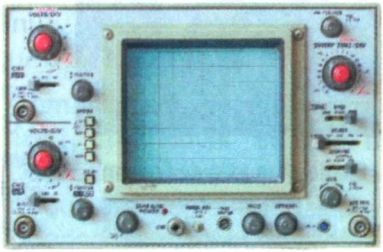
mega ohmmeters used. A micro ohmmeter measures extremely low resistances with high accuracy whereas a milli ohmmeter measures the same and confirms the value of any electrical circuit. A mega ohmmeter measures large resistance values.

There is a device called Fluke micro ohmmeter. It is used to measure voltage, current, and test diodes.

What is an oscilloscope?

In simple terms, an oscilloscope is a type of equipment that provides visual images of varying electrical quantities. That means that its main function is to graph an electrical signal as it changes over time. Most oscilloscopes produce a two dimensional graph showing time on the x-axis, and voltage on the y-axis. The signals produced are plotted on a graph.

There are a number of applications for which oscilloscopes are used. Most of the general purpose instruments are used for maintenance of electronic equipment and laboratory work. It is an important tool for designing, or repairing electronic equipment. Special purpose oscilloscopes are used for analysing an automotive ignition system or to display the waveform of the heartbeat as an electrocardiogram.

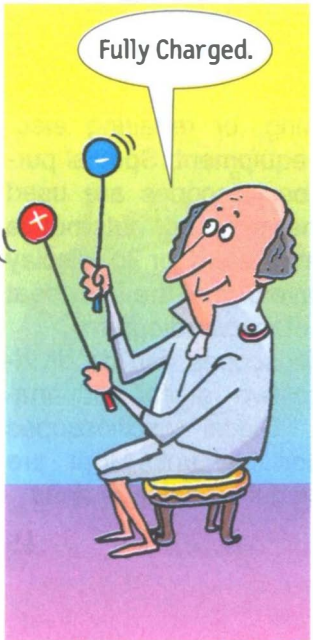


Oscilloscope

Oscilloscopes can be divided into two- digital and analogue. Digital oscilloscopes are portable units that are replacing the analogue ones.

SOME LAWS THAT DEFINED ELECTRICITY

Charles Augustin de Coulomb



Why is Coulomb's law one among the basic laws of electricity?

Many scientists have, in the past, tried to study the features of charged particles, and the force they exert on other charged particles. But the reason behind this remained a mystery until the French physicist Charles Augustin de Coulomb put forward his theory on the same.

Coulomb's law, as it is known all over the world describes the electrostatic interaction between electrically charged particles.This law was first published by Coulomb in 1783.

Let's see what it says. Suppose there are two charged particles. With these is created an electric force. If the charges are stronger, the forces they create will be stronger too. This is the basic idea behind the law. Coulomb also found out that either attraction or repulsion acts along the line between the two charges.

A decade earlier, British scientist Henry Cavendish also made similar observations, but he did not publish them. So, most of the credit went to Coulomb alone.

Georg Simon Ohm

Why is Georg Simon Ohm considered to be a great scientist?

Georg Simon Ohm was a German physicist who formulated the 'Ohm's Law'.

It states that current flow through a conductor is directly proportional to the potential difference or voltage, and inversely proportional to the resistance. The law was important, because it marked a successful start to the analysis of electric circuits.

In 1827, Ohm published his book titled 'The Galvanic Circuit Investigated Mathematically' in which the Ohm's Law first appeared.

Although it was later treated as an important work that influenced the theory and applications of electricity, the book did not receive enough acceptance when it was published. It is said that Ohm resigned his post as a teacher from Jesuit Gymnasium of Cologne due to this.

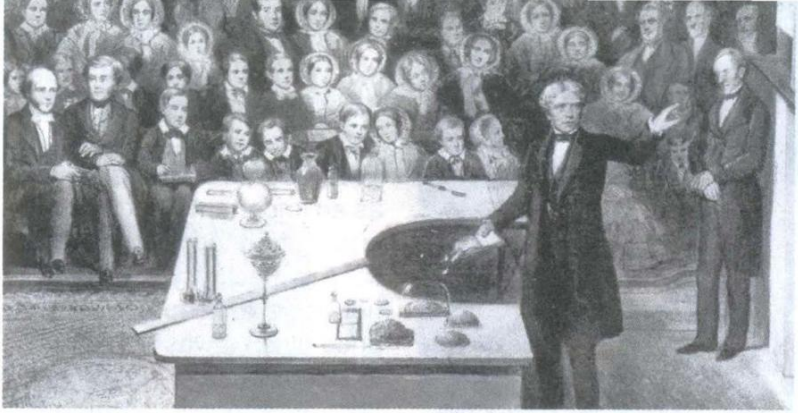
A few years later, Ohm's Law started getting noticed, and Ohm was appreciated. In 1841, the Royal Society of London awarded him its prestigious the Copley Medal considering his contribution.

The physical unit measuring electrical resistance 'ohm' was named after him.

Why is Faraday's law important?

The concept of electricity cannot be complete without Faraday's Law of induction. It describes how changing magnetic fields can cause electric current to flow in a conductor.

The working principle of electric motors, transformers,



Faraday's Lecture

generators, are all based on Faraday's Law of Induction.

Faraday discovered electromagnetic induction in 1831. He had conducted many experiments before concluding his theory. He experimented with magnetic fields that stayed the same, and realised that they do not induce current.

Then he experimented by changing magnetic fields, and saw that they induced current and voltage.

STAR FACT

First of its Kind

France and the United Kingdom were the first nations to support the widespread development of electric vehicles. The first known electric car was built in 1837 by chemist Robert Davidson of Aberdeen. It was powered by galvanic cells.

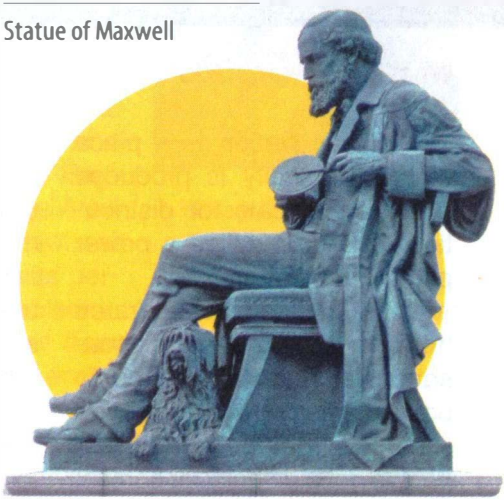
Faraday's discovery of electromagnetic induction did not receive much acceptance from scientists when it was introduced. But Scottish scientist James Clerk Maxwell realised its importance, and used the ideas as the basis of his quantitative electromagnetic theory.

Why is Maxwell's equation known as the foundation of classical electromagnetism?

Maxwell's equations refer to a set of four equations that describe the creation and propagation of electric and magnetic fields. They are named after the Scottish physicist James Clerk Maxwell, who made significant contributions to unify the theories of electricity, magnetism, and light. The early form of these equations was published between 1861 and 1862, and it proposed that light is an electromagnetic phenomenon.

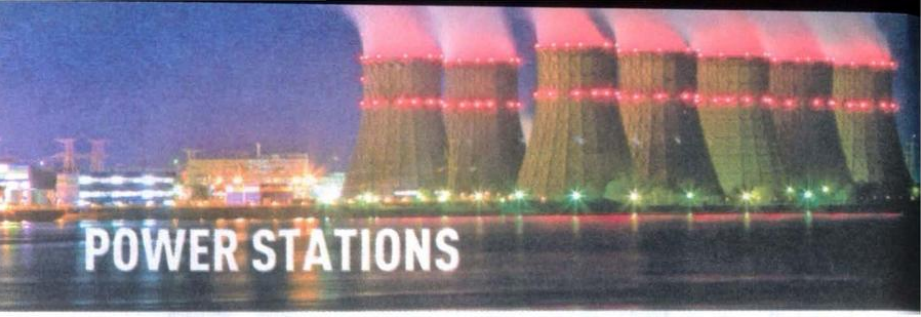
The equations formed from these laws could give an explanation to many phenomena around. For instance, how hair stands on end when one removed a nylon sweater,

Statue of Maxwell



how a compass needle points north all the time, how a power station turbine generates electricity etc. Together, they could also describe the transmission of radio waves, and the propagation of light.

Hence, Maxwell's equation, along with the Lorentz force law, is said to form the foundation of classical electromagnetism. Lorentz force law describes the force acting on a moving point charge 'q' in the presence of electromagnetic fields.



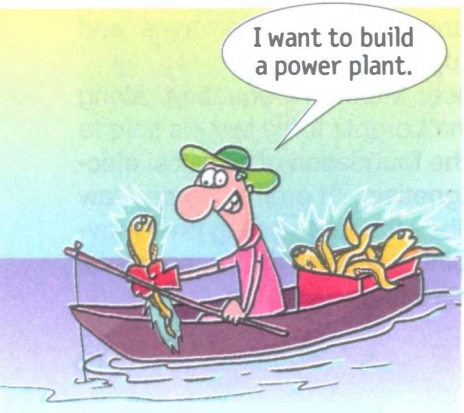
POWER STATIONS

What are power stations?

A power station is a place where electricity is produced on a large scale for distribution. It is also called a power plant, or power house.

The electricity generated here, mostly in several thousand watts, is transmitted to power grids through power lines. It is from these grids that people get electricity for homes, schools, businesses etc.

A majority of the power stations in the world burn fossil fuels to generate electricity.



A Nuclear Power Plant

This includes coal, oil, and natural gas. They are called thermal power stations.

There are also plants that use nuclear power instead. It is said that over 11 per cent of the world's power is produced by nuclear power stations.

But these days, there is an increasing use of renewable resources like solar, wind, wave and hydroelectric powers for electricity generation.

At the centre of almost all power plants there are AC generators, or alternators. The machines convert mechanical power to electrical power.

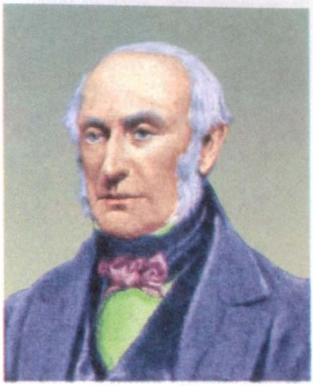
In 1882, Edison established the Pearl Street Station, a power plant that provided electric lighting in Manhattan. The station ran until destroyed by fire in 1890.

Why is it said that the history of hydroelectric power stations begins in London?

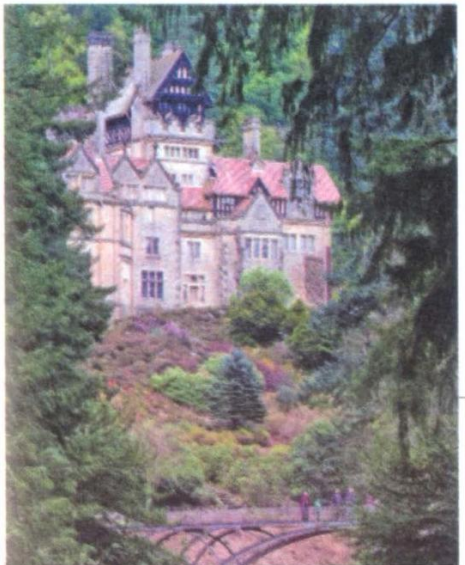
Hydroelectric power plants use the force of falling water to generate electricity. It's one of the safest sources of energy that is also reliable and cheap.

Some of the earliest hydroelectric power plants were set up in and around London. In the 1870s, English industrialist William George Armstrong built one such plant at Cragside, in England. This was perhaps the world's first hydroelectric power scheme. It used water from the lakes on his estate to power the generator.

In 1882, a central station was built in Godalming, England, using hydroelectric power. This time, it was to provide street and household lighting to the public. But this project ended up as a failure.



William George Armstrong



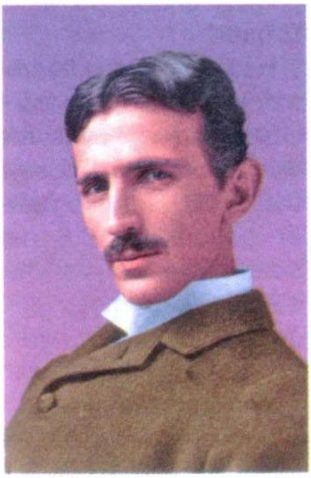
Cragside

However, many hydroelectric projects were conceived all over the world by then. It is said that in 2015, hydro power generated 16.6 per cent of the world's total electricity. Almost 150 countries have hydro power plants today, with China being the largest producer of hydroelectricity.

Energy Producers

Together, fossil fuel power plants and nuclear power plants provide approximately 80 per cent of the electricity needed for the world.

● *Ryan Thomas*



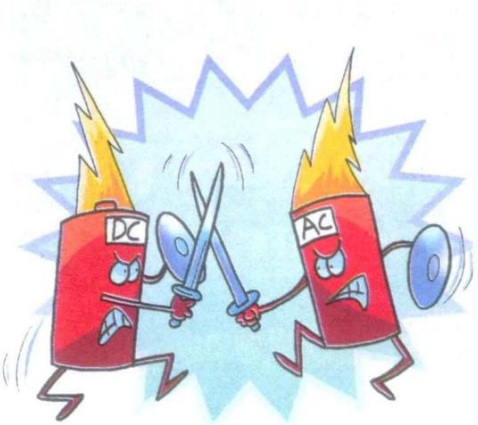
Nikola Tesla

What is meant by the 'War of Currents'?

The 'War of Currents,' was the term used to refer to the dispute between two brilliant inventors-Thomas Alva Edison and Nikola Tesla. It happened towards the end of the 19th century, when there arose a question over which was better-direct, or alternating current.

Edison was the brains behind the development of DC, which ran continually in a single direction. In the early years of electricity, DC was regarded as the standard. But it had a problem; it couldn't be easily converted to higher or lower voltages.

Tesla strongly believed that alternating current was a solution to this. AC, which he co-developed could reverse its direction unlike DC, and



A Thermal Power Plant

could also be converted to different voltages using an electrical transformer. It made possible long distance electricity transmission too.

However, Edison saw Tesla's argument as a threat to his work. He thus started off a public campaign, trying to discredit AC. The main reason for the campaign was that Edison did not want to lose the royalties he had been earning from his DC patents.

But in spite of all the efforts Edison made, it was Tesla and his AC that won in the end. Today, electricity is mainly powered by alternating current.

Why is it said that thermal power stations are common?

A thermal power station is where heat energy is used to generate electricity. It is the most conventional, and common source of electric power.

Let's see how it works. A thermal power plant burns fossil fuels like

CURIOUS FACT

Obsessions

Serbian-American inventor Nikola Tesla was known to have an obsession for the number '3'.

Chimneys of a Thermal Power Plant

coal, oil, and natural gas to produce steam. The steam thus formed, creates a pressure that spins the turbine inside the plant. Electric power is generated by these spinning turbines.

The advantages of a thermal power plant is that it requires less initial cost, and less land compared to other power stations. The fuel used - fossil fuel- is also cheap. Many countries in the world depend mainly on thermal power for electricity. It is said that around 40 per cent of the world's power is made out of fossil fuels.

However, thermal power plants have been criticised for the pollution they cause, due to the large amount of smoke and carbon dioxide emitted. This is a cause of global warming. Besides, the overall efficiency of a thermal power station is below 30 per cent.

What makes hydroelectricity more acceptable than the electricity produced by thermal power stations?

As we saw earlier, hydroelectric power plants make use of the force of flowing water to generate electricity. There are many reasons why experts hold that hydroelectricity is more acceptable than the other. One of the most significant advantages is that hydroelec-

tric power plants do not require any fuel for power production. They only need water, a renewable source of energy. Thermal power stations need fossil fuels like coal, natural gas, oil etc., to function.

Since no fuel is required, the cost of electricity produced by hydroelectric plants is also somewhat constant. In the case of other kinds of plants, it depends on the cost of fuels in the international market.

Another important factor is pollution. Hydroelectric power plants do not burn fuel; hence do not cause pollution either. The heated water that comes out of them threatens aquatic lives too.

Hydroelectric plants also have longer lives compared to thermal plants. Besides these, hydroelectric plants are known to facilitate irrigation of farms and preventing floods.

Hence, around 150 countries in the world use this technology for power generation.

How is electricity produced in hydroelectric power stations?

As we know, it is flowing water that creates the energy required to generate electricity. Wonder how it works?

Well, there is a huge amount of energy created from the falling of water. This energy is harnessed by forcing it through a pipe, which is called a penstock. At the end of the pipe,

A Hydroelectric Power Plant

Solar Cells

Solar cells are used to power portable devices like calculators. They are also called photovoltaic cells.

there is a turbine propeller. So, when water flows through the pipe, it reaches the propeller, and turns the blades of the turbine. This spins an electric generator. Hence, as long as water is flowing, the generator will be spun, and there will be electricity.

There are mainly three ways in which hydroelectric plants are designed.

The most common type follows a storage system. To put it clearly, there is a dam used in this system. It slows the flow of a river and stores the water in a reservoir above it. When needed, a portion of the water is released into the river flowing below the dam. The pressure thus created from the fall of water, spins turbine generators lying below. From this is created hydroelectricity.

Yet, another is the run-of-the-river system. Here, turbines are spun by the natural flow of the river.

The third type follows the pumped storage system. This is similar to the first type of storage system. But the difference is that it uses pumps to pump the used water back into the reservoir.

How do solar power plants work?

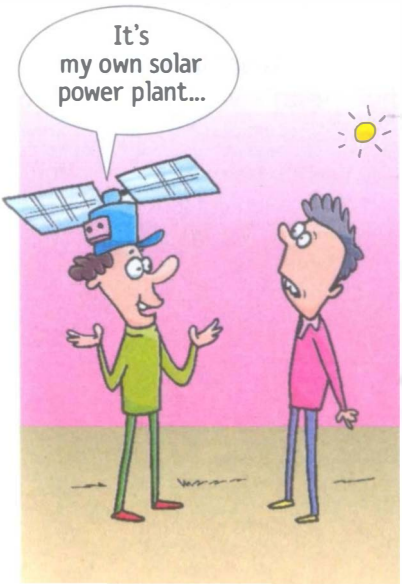
As the name suggests, solar power plants use sunlight for power production. There are two different technologies used for solar power production these days- using photovoltaic plants and solar thermal systems.

Photovoltaic cells, or PV cells, produce electric current when exposed to light. They are also called solar cells. They contain silicon, a naturally occurring element found in sand. When sunlight hit silicon, there happens a chemical reaction. As a result, electrons move, and electric current

A Solar Power Plant

is produced. A group of PV, or solar cells create a solar panel. A number of solar panels form a solar array, and they generate solar energy.

In solar thermal systems, sunlight is collected and concentrated to produce high temperature heat that is needed to generate electricity. All the systems have solar energy collectors with two components- a 'reflector' that captures and focus sunlight onto the 'receiver'. In the system here, a heat transfer liquid is heated and circulated in the receiver. It is used to produce steam. The steam is then converted to mechanical energy in a turbine, which powers a generator to produce electricity.



Why is it said that the wind and tides are the best way to produce electric power?

The wind is a major source of renewable energy that is also useful to generate power. You must have seen windmills in

real life, or on television. They are set up on farms for power generation.

Although they look like fans, windmills work in just the opposite way. In fans, electricity is used to make wind, but in windmills, wind is used to make electricity.

Let's see how they work. When the wind blows, it turns the blades of the windmill. This in turn, spins a generator inside, and produces electricity.

A single windmill can generate only a small amount of electricity. Hence, power companies build wind farms with a large number of wind turbines.

In many countries including Denmark and Portugal, wind power contributes largely to power production.

Yet another form of energy comes from ocean tides, which again, can be used to produce electricity. Just like wind turbines, there are tidal turbines too. They are turned by ocean currents. The spinning turbines are connected to devices that generate electricity.

Here again, the process and products are safe, as there are no harmful emissions made.

Why is osmosis and biomass much less used source of electricity generation?

Osmotic power is the energy that comes out of the difference in salinity between sea water and fresh water. This

Wind Turbines

energy can be harnessed to generate electricity.

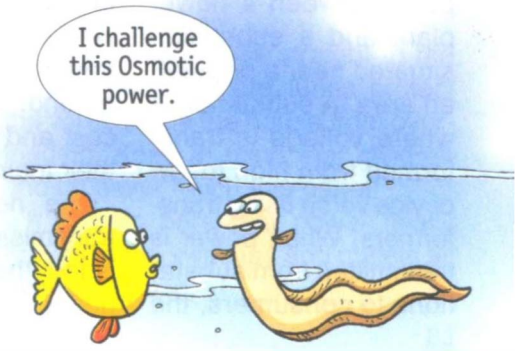
Sounds strange, doesn't it? Let's see how this happens. When we separate fresh water from sea water by a semi permeable membrane, we can see that the fresh water moves through the membrane into the seawater. This happens by a process called osmosis. It means the movement of something from a less concentrated solution into a concentrated one.

There is a pressure created by the process of osmosis. This pressure combined with the permeating flow rate together, turns a hydraulic turbine, and produces electricity.

Statkraft, the Norwegian energy firm was the world's first test plant that harnessed osmotic power. Experts note that there are many advantages to this kind of power production over others. However, the biggest challenge this technology faces is the cost. Osmotic power plants are just too expensive to install.

An offshore wind farm of Statkraft

Yet another renewable energy is biomass, a fuel that is developed from organic materials like certain crops, manure, forest debris etc. In biomass power plants, waste is burned to produce steam that runs a turbine, producing electricity.



FROM PLANT TO HOME

A Sub Station

What is meant by the term electric power transmission?

Electric power transmission means the transfer of electric power from one place to another in large quantities.

Typically, this happens between a power plant and a substation situated near a populated area. A substation is where voltage is transformed from high to low or vice versa using transformers. When power is transmitted from substations to consumers, the process is called power distribution. Normally, transmission takes place at very high voltage, like 110 kV or above. This is because of the large amount of power involved in this.

Over long distances, electricity is transmitted through overhead power transmission lines. But in places that are environmentally sensitive, or where there is very high population, transmission takes place underground. They have high installation cost and operational limitations, yet their maintenance cost is lower.

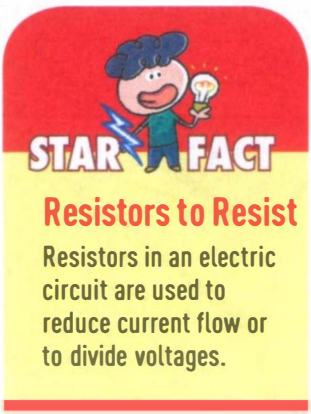
The network of power stations, transmission lines, and substations is together known as a transmission grid.

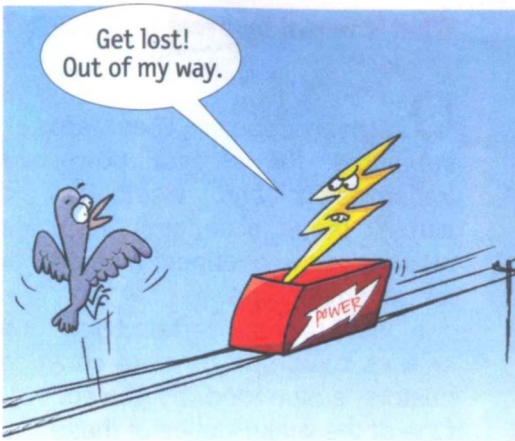
How does electricity come to our home?

From the moment power is generated in a plant, it goes through various stages before reaching our homes.

Let's see how power travels. From the electricity generating plants, current is sent through transformers to increase the voltage, so that it can be pushed longer distances.

Electric power then reaches a substation. Here, the voltage gets lowered, so that it could be sent to smaller power lines.





From there, it travels through various distribution lines, and reaches your neighbourhood where smaller transformers reduce the voltage, so that you can take safe power to your homes.

From the transformer, power is carried through service drops, or smaller overhead electrical lines to your homes. It also passes through the 'meter' installed in the house that can measure how much power is used by the family.

The current moves straight to the service panel, where fuses protect the wires inside the house from overloading. Keep in mind that children should never touch this panel!

It is from here that power finally moves to the switches and outlets all over the house.

What is meant by overhead power lines?

Overhead power lines are structures for electric power transmission and distribution across large distances. They also make the cheapest method for transmitting power.

In usual cases, overhead power lines have one or more conductors suspended by towers. One of the major duties of these power lines is to maintain enough space or clearance between these energised conductors and the ground, in order to avoid danger.

These days, power lines can be operated at voltages of 765,000 volts or even more, between conductors. Depending on their range of voltages, overhead power lines can be classified as low voltage, medium voltage, high voltage, extra high voltage, and ultra high voltage.

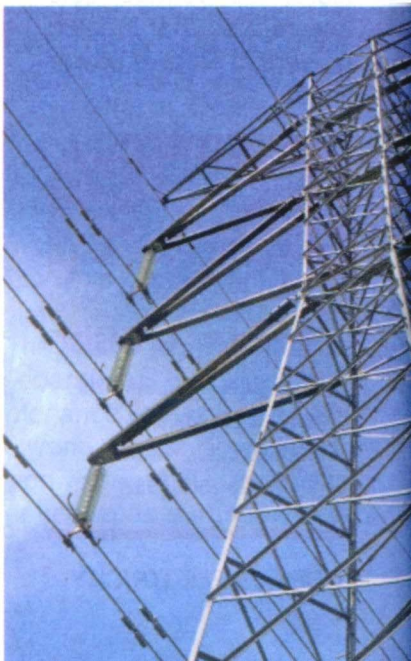
However, these power lines are extremely dangerous, and one has to keep a safe distance from them. Unlike household power cords, overhead power lines are not insulated. Even if it looks like an insulation, it might be a weatherproofing material.

Why is it said that transformers play a major role in electric power distribution?

A transformer is an electrical device that transforms electricity from high to low voltage and vice versa. It is an important component for power transmission. Let's get to know why.

We saw the process through which electric power reaches our homes. When electricity travels from a power plant, it comes in a

A High Voltage Transmission Tower



Diodes

A diode is an electric component made of semiconductor materials like silicon, germanium or selenium. It has two electrodes in it- the anode and the cathode.

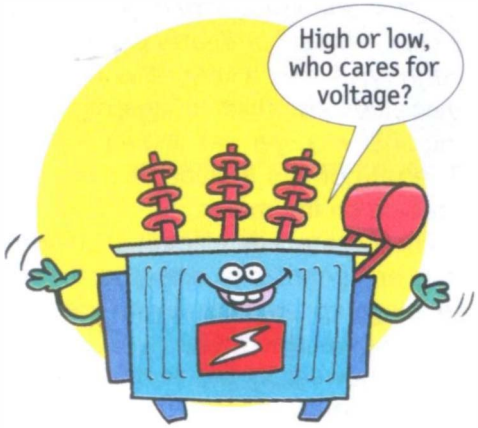
• *Sneha Rao*

very high voltage. This is because the voltage from the plant is 'stepped up' by transformers before they are transmitted.

The voltage has to be increased because electric power has to travel very long distances, and that too, with minimal loss of energy. We should know that energy is lost in the process of power transmission. But if the voltage is high, energy loss would be low.

A Step Down Transformer

But do our homes need this kind of voltage? Absolutely not! Before the power reaches houses, the voltage has to be lowered, or stepped down. This is where transformers again become important. They step down voltage from high to low.



ELECTRICITY IN HOMES

Why is the electric meter an important equipment in houses?

Electric meters are devices that we commonly see in houses and offices. They are used to measure the total electrical energy consumed by the appliances in a house or office. The devices are installed by the electric power company that supplies electricity.

If you take a close look at these meters, you can see a few digits. They denote the number of units of electricity that has been consumed so far. Our electricity bill depends totally on this reading.

There are different types of electric meters available in the market. One is the electro-mechanical meter, which is most commonly used in our country. It has a magnetic metallic disc attached, which rotates, depending on the power passing through it. The rate of this rotation decides the reading on the meter.

Then there are electronic meters that are popular in cities. In these, readings appear digitally on the display fixed on the meter.

The newest in this league is the smart meter. They are electronic meters, but they have an added advantage. These smart meters are connected back to the

An Electric Meter

utility (which provides us electricity) through the internet. Hence, no official will have to come in person and take the readings. The readings are sent through the internet, which makes the job easier.

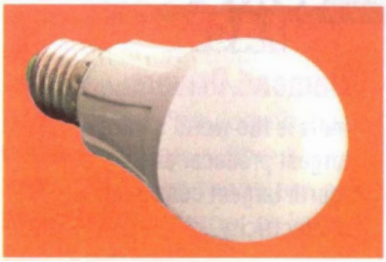
What is the measuring unit of electricity?

Electric power is always represented in terms of watts (W) or kilowatts (kW). A thousand watts together make a kilowatt.

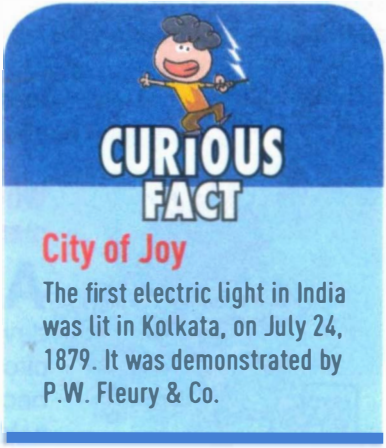
Watts describe the rate at which electricity is consumed during a specific period. Take the case of a 15-watt LED bulb. It draws 15 watts of power at any moment when turned on.

Let's look at other examples to understand the concept better. The power rating of a typical incandescent light bulb used in houses is between 25 to 100 watts. To produce a similar amount of light, fluorescent lamps consume 5 to 30 watts, and LED lamps use 0.5 to 6 watts.

Coming to power stations, a typical power station that uses coal to generate electricity produces around 600 to 700 megawatts. A megawatt is equivalent to one million watts! The term 'watt' was named after James Watt who developed the steam engine. Watt-hour is quite different from a watt. It is a measure of electrical energy equivalent to a power consumption of one watt for one hour.



An LED Bulb


CURIOUS
FACT
City of Joy
The first electric light in India was lit in Kolkata, on July 24, 1879. It was demonstrated by P.W. Fleury & Co.

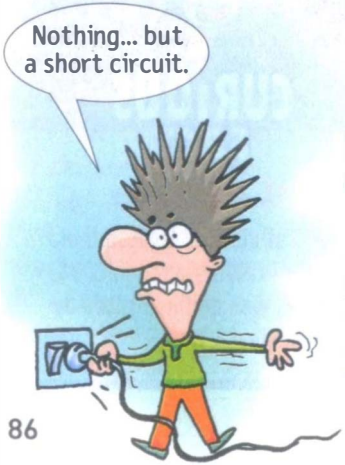
CURIOUS FACT

Demand Drivers

India is the world's third largest producer and fourth largest consumer of electricity.

What is meant by a short circuit?

Short circuit is a term we hear often, and it is something that is dangerous, for sure. Let's see what exactly a short circuit is.

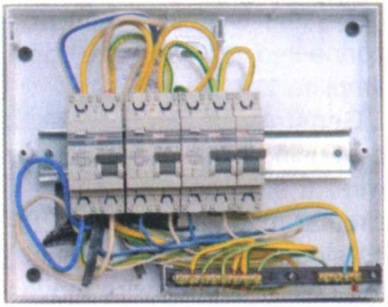


It is a problem that arises when two or more wires in an electrical circuit, that are not supposed to come in contact, touch each other. This action is immediately followed by a very high current flowing through the circuit. This can result in a lot of dangers, like sudden fire, destruction of the components in the circuit, or melting of insulation. Sometimes there can also be an electrical explosion, or what is known as an 'arc flash'.

Scary, isn't it? However, there are fault protection devices like circuit-breakers and fuses that can detect a short circuit.

Why is the fuse an important equipment?

As we saw earlier, a fuse is a device that is provided in an electrical circuit to protect the appliances connected to it from damage. It is a safety tool that limits current in a circuit.



Circuit-breakers

Structurally, a fuse is a short piece of wire made up of elements like zinc, copper, silver, aluminium, which have high resistance, and a low melting point. In case of overheating due to excess current, the fuse tends to melt and separate. It thus prevents fire outbreaks and also protects humans from electric shock.

Fuses, in general, are used in all types of electrical and electronic applications.

Depending on their uses, there are different types of fuses available. One is the cartridge fuse, which is used to protect electrical appliances like motors, air-conditioners, refrigerators, pumps etc., where high voltage rating and currents are required.

Then there are blade type fuses that come in a plastic body with two metal caps, to be fitted in a socket. These fuses are mostly used in automobiles for wiring and protection from short circuit.

Another category is of resettable fuses. They can be used multiple times without being replaced. Such fuses are seen in nuclear systems, or in aerospace systems.

Why is it said the introduction of the telegraph, telephone, and loudspeaker are a culmination of electricity?

Telegraphy, a technology developed in the early 18th century, revolutionised long-distance communication. It was a simple electrical circuit that transmitted electric signals over a wire, between stations.

Telegraph Equipment

Old Telephone

Through the telegraph lines, messages could be sent back and forth as bursts of electricity. It was the connection between electricity and magnetism that led to this path-breaking invention.

By the end of the 19th century, another invention surfaced- the telephone. It was a different and advanced device that improved communication between long distances. In a telephone, an electric current carries the sound. Here again, the invention followed the principle of electromagnetism.

Another important device that works on the same principle is the loudspeaker. It converts an electrical signal from devices like a radio, or television into sound. For this purpose, the signals have to be connected to an electronic amplifier.

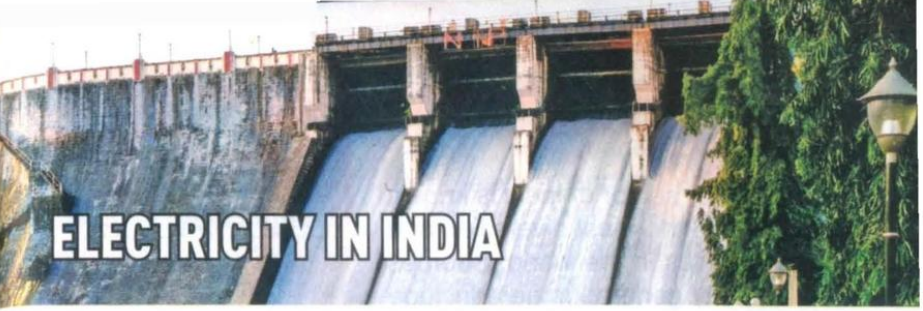
Generally, a loudspeaker is built using a coil of thin copper wire, a still paper cone and a circular magnet. When electrical signals are passed through, the coil of copper wire moves back and forth. This, along with the magnet, cause the paper cone to vibrate and reproduce sounds.

Taking into consideration the above mentioned devices, as well as other equipment, one can say that no invention in recent times has been complete without electricity.

Gone with the Wind

India is credited with having the fifth largest wind power capacity in the world. Wind power accounted for 9 per cent of the country's total power capacity in 2015-16.

● *Devnath*

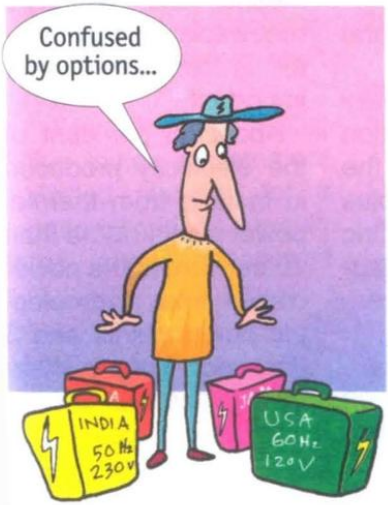


ELECTRICITY IN INDIA

Why is it said that electricity distribution is different in every country?

The electrical sector of any country in the world depends mainly on its economic system, and policies adopted by its government.

Hence, the whole process of power production and transmission in a country need not be the same as others. In some of them, generation, transmission and distribution of electricity is done by a government controlled organisation. But in some others, privately owned companies will have shares too.



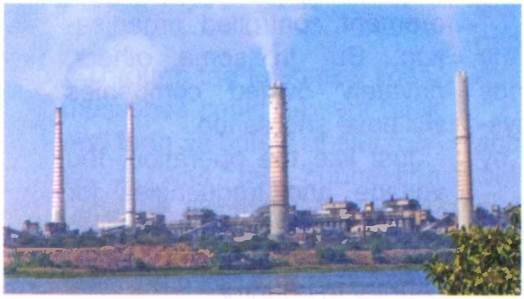
Just like the operation, the voltage and frequencies for providing electrical power to appliances too, differ from country to country.

In India, 50 Hz and 230 volts of power is distributed for domestic and industrial purposes. Countries like Hungary, Italy, Indonesia, Germany, France, and Russia too, follow the same pattern. But the USA and Canada have a different scheme- of 120 V and 60 Hz.

In Pakistan, Iran, and China it is 220 V and 50 Hz, and in Japan it is 50/60 Hz and 100V. This means, every country has differing rules regarding distribution of power.

Why is it said that India is a giant in the production of electricity?

The power sector of India is known to be one of the most diversified and powerful ones in the world. Sources of electricity generation here include conventional sources like coal, natural gas, oil, lignite, hydro and nuclear power, and also non-conventional sources like solar, wind, agricultural and domestic waste.



Thermal Power Plant at Kota, Rajasthan

The country has witnessed a very fast growth in electricity generation since 1990. In the year 2015, the country became a power surplus nation that possessed huge electric generation capacity. But many villages in India do not have power connection even now.

By mid-2016, India's power generation capacity crossed the 300,00 MW (megawatt) mark, including more than 42,848 MW renewable energy sources such as solar and wind power plants. This means, the country's renewable energy sector is considered very important.

About 65 per cent of the electricity produced in India is from thermal power plants. More than 20 per cent of the power comes from hydroelectric power plants and 3 per cent from nuclear plants. The rest is from alternate sources.

Gifted

With the inauguration of a dedicated solar plant, the Cochin International Airport Limited (CIAL) became the world's first fully solar-powered airport, on August 18th, 2015.

Why is it said that India's grid management system is unique?

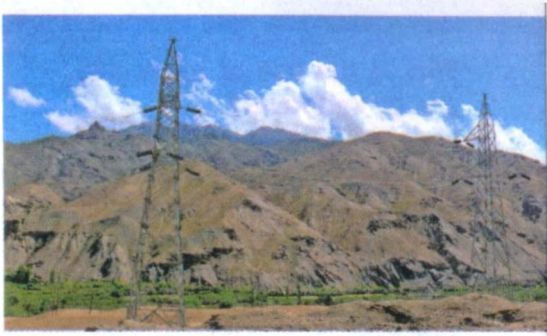
A power grid refers to an interconnected network for distributing electricity to consumers.

It was in the 1960s that India began utilizing the grid management system on regional basis. The power grid system was then geographically divided into five regions for better management. These regions are- northern, eastern, western, north eastern and southern grids.

They were established to enable the transmission of surplus electricity between states in each region.

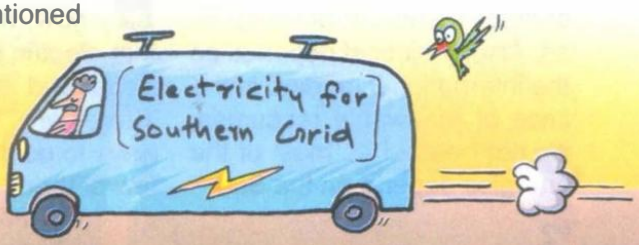
Towards the 1990s, the Indian government started planning for a national grid. As a result, the above mentioned regional grids were interconnected.

In October 1991, the first interconnection was made, between the north eastern and the eastern grids. A few years later, in 2003, the western grid got connected with the above. This process followed in the later years as well. The northern grid was also interconnected in August 2006.



High Voltage Electric lines in the Himalayas

In December 2013, the remaining grid- southern- was connected to the central grid in a synchronous mode. Thus, the aim to build 'One Nation- One Grid- One Frequency- was achieved.



SAVE FOR TOMORROW

Eco-friendly options for Power Generation

Why is the use of renewable energy important?

There are many reasons why renewable energy is important for the world and its future.

The main advantage of these energies is that they are free of pollution. Renewable resources are way cleaner than fossil fuels because they don't produce toxic wastes.

Next, the reserves of these energies are never ending unlike coal, gas, oil or nuclear sources. Hence, they're named renewables!

Power production from fuels and other non-renewables demand a large-scale import of these resources at high prices. Also, their cost depends on the international market. In the case of renewable resources, it's not needed as most of the energies depend on the Sun.

There are many countries that depend largely on renewable resources. For instance, Denmark, UK, Scotland and Ireland make great use of wind energy.

Denmark, which has been a pioneer in the field, gets around 42 per cent of its power from wind plants.

And there are countries like China, and India that use of hydro power for electricity, which is equally safe.

How do we save electricity?

By now, we should all know that electric power is very precious and has to be saved. There are of course many ways to do that. Let's look at a few of them.

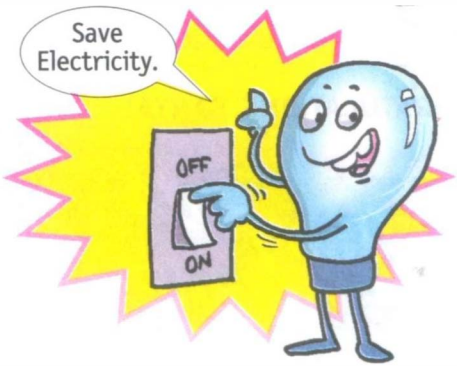
The first and foremost step is to make sure that any appliance is turned off when not in use. For lighting, you could use LEDs or CFLs instead of incandescent bulbs. And if it's daytime, try to make use of the day light instead of other lights. They could very well serve the purpose!

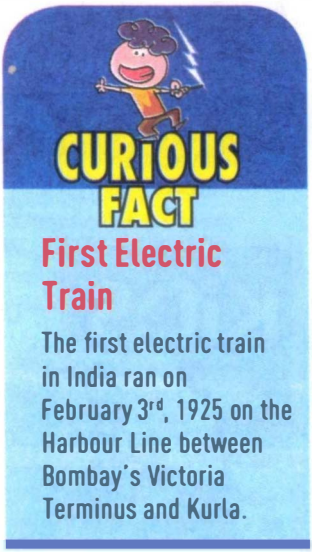
The next thing to remember is that electrical appliances should never be left on standby. It's a major waste of power. A TV consumes 10 watt power in standby mode.

If you are using an air conditioner, make sure the doors and windows are closed, so that the power is not wasted. But any day, ceiling fans are recommended instead of coolers and air conditioners.

The appliances that account for a big chunk of your electricity bill are refrigerators, air conditioners, washing machines etc. And as they get older, power consumption too goes up. So, old appliances should be replaced by energy-saving models on time, so as to save power.

These are some of the methods you can try to save power in homes.




CURIOUS FACT
First Electric Train
The first electric train in India ran on February 3rd, 1925 on the Harbour Line between Bombay's Victoria Terminus and Kurla.

NATIONAL GEOGRAPHIC KiDS

INTERNATIONAL PHOTOGRAPHY CONTEST 2016 FOR KiDS

Sanya Jain
Class VII E
Army Public School,
Ambala Cantt,
Haryana.

International Winner in the 'Wild Vacation' category.

MOMENT OF PRIDE FOR NG KIDS INDIA

One of our entries wins an international prize.

The National Georgraphic Kids recently held a world-wide photography contest for children. The various national editions conducted separate contests, and the international winners were chosen from the first-prize winners in various countries.
One of the Indian winners, Sanya Jain (12) from Haryana, has been chosen as an international winner, in the 'Wild Vacation'category.

CONGRATULATIONS, SANYA!

Congrats Winners

NATIONAL WINNERS

WILD VACATION

1. SANYA JAIN
27 Coy ASC Sup Ambala Cantt, Geeta Gopal Chowk, Ambala Cantt, Haryana 133001.

2. BENJAMIN MATHEW
#313, 2EC, HRBR 3rd Block, Old Ramaiah Layout, Kalyan Nagar, Bengaluru 560084.

3. SHAYAN S
House Number 17, A Block, KMC Staff Quarters, Light House Hill Road, Mangalore 575001.

DARE TO EXPLORE

1. NEERAJ NANDAKUMAR
28/145, Shobhendu, Thondayad, Chevarambalam Post, Kozhikode, Kerala 673017.

2. AARUSHI CHAKRABORTY
Sovereign Park, FF-2 , No-38, 1st Main Rd, Chinnana Layout, KB Sandra, PO- R.T. Nagar, Near Ambedkar Medical College, Shampura Rd, Bengaluru 32.

3. KEVIN GEORGE MATHEW
C/o Vipin Varkey, M6/29, Mukkuzhickal, KSHB Housing Colony, Malaparamba PO, Kozhikode 673009.

WEIRD BUT TRUE

1. SHRIRAM SUYOG JOSHI
Gokul,51-A, Vrindavan Hsg. Soc., Panchavati, Pashan, Pune 411008.

2. SREERAM CHENGALOOR
Flat No. L1, Green Court Apartment, 8th Main, 4th block, Srinidhi Layout, Vidyaranyapura, Bengaluru- 560097.

3. DHURAI A.NAVANEETHAM
124-S1, SRP Colony 2nd Street, Periyar Nagar, Chennai 600082.

AMAZING ANIMALS

1. AIKA NIKHIL
B-4, Uttarayan Apartment, Bachaspati Para, P.O. Talpukur, Barrackpore, Kolkata 700123.

2. KETAN DAS
E-180, Sector-21, Noida, Uttar Pradesh 201301.

3. HRUDASREE R. KRISHNAN
Flat 4C, Asset Lineage, Pipinmoodu, Sasthamangalam, Trivandrum 695010.

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33. Ms. Aditi Mammen, No.6, Riverside Road, Kotturpuram, Chennai- 600 085
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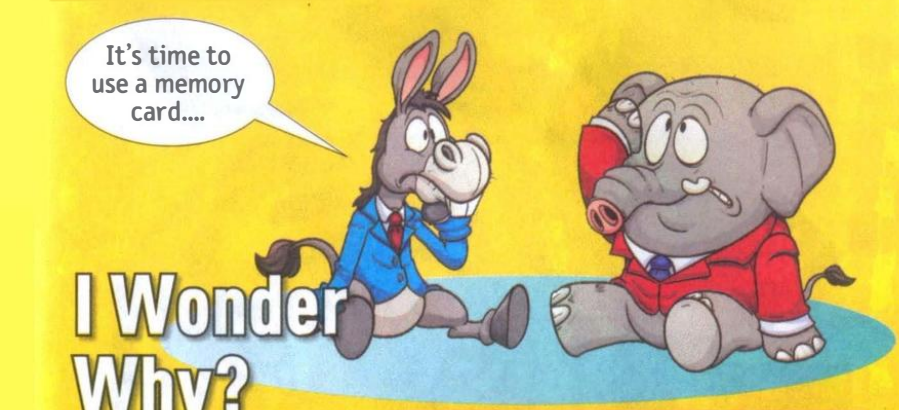
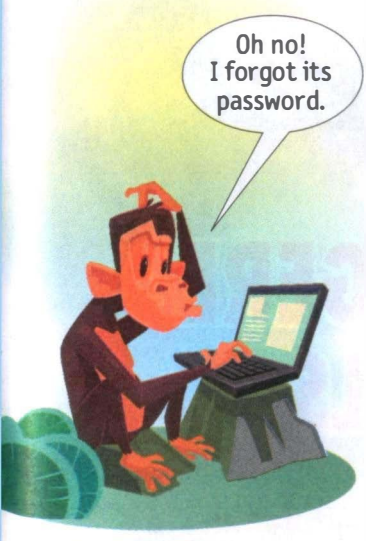


I Wonder Why?

Question of the Month



Question sent by:
Aman Agarwal, Delhi.

Send us your questions
E mail: **tellmewhy@mmp.in**

Why do we forget things?

As we all know, our brain is a brilliant magician. It allows us to do amazing things like learn multiple languages, and solve complex mathematical problems. But the very same wizard, at times, deceives us by forgetting things.

Why do we forget things? Scientists suggest many theories behind this strange behaviour by our brain. Most prominent among them is decay theory which states that our memory slowly disappears with the passage of time.

Another theory is interference. This means that when we get some information similar to information already stored in our memory, it is likely that we forget the new information. Strange but true!

NEXT ISSUE

ENDANGERED ANIMALS

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MANORAMA TELL ME WHY - STORY OF ELECTRICITY

Chief Editor: Ammu Mathew Editor-in-Charge: A.V. Harisanker *

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